EDUCATION AND THE YOUTH OF GREAT BRITAIN

THE debates on the Crowther Report, in the House of Commons on March 21 and in the House of Lords on March 23, were noteworthy for the statements of Government policy made by the Minister of Education and the Minister for Science, although the Government had already indicated its acceptance in principle of the recommendations both of the Crowther Report and of the Albemarle Report on the youth service in England and Wales. The debates, moreover, brought out the way in which, to some extent, the recommendations of the two reports are interlocked; and, particularly in conjunction with earlier debates in the House of Lords on the problems and opportunities of leisure, on March 2, and on adult education, on March 16, they also helped to clarify a number of the main issues involved and the points at which action is imperative. Moreover, appropriate action is not solely the responsibility of the Government; speaking in the debate of March 2, Lord Hailsham, referring to the acceptance of those recommendations of the Albemarle Report which require Government action, said that the Government would as soon as possible be discussing with the local education authorities the part they should play, and that the Minister of Education desired him to lay great stress on the need for voluntary effort.

So far as leisure is concerned, Lord Hailsham himself believes that the vital role of education is in the inculcation of right standards, and that here the critical battleground is in the home, with the school as an invaluable ally. In this he thinks the technical colleges as well as the schools have an important part to play: full-time education gives the best opportunity of instruction in the art of using leisure, and the key place now occupied by scientists and technologists in modern life makes it imperative to seek to increase their awareness of the economic and social importance of their work. Here Lord Hailsham referred incidentally to the value of educational research—a topic that received a remarkable amount of attention in the later debates on the Crowther Report. For the rest, however, on this occasion Lord Hailsham was concerned to stress the limitations placed on Government initiative in a free society if the use by the individual of his faculties is to be encouraged and not undermined.

While the Crowther Report and its recommendations have already been discussed in these columns, beyond the general acceptance of these recommendations in principle little was known of the Government's intentions. These have been made much clearer by Sir David Eccles's speech on March 21, in asking the House of Commons to welcome the Report. Sir David said at once that the Government accepts its major recommendation that the school-leaving age should be raised to sixteen provided the extra year in full-time education can be spent either in school or in a technical college, but he questioned the desirability of fixing the date now before we have ensured that the necessary conditions can be fulfilled, particularly as there is already a strong tendency for more children voluntarily to stay on after the age of fifteen.

The four pre-conditions specified by Sir David are, first, school buildings adequate to accommodate the extra pupils; competence to hold the interest of the 15–16-year-olds; sufficient teachers; and a public opinion which fully supports this step. As regards the first, he believes that if the resources were made available, we could provide the total building requirement of about £80 million for England and Wales in four years before the date suggested for raising the age. In many secondary schools the teaching staff has not yet had a fair chance to provide satisfying courses for the *C* and *D* streams in their last year, and while the Crowther Council is confident that the schools could be so much improved by the late 1960's that Government need not be afraid to name the date now, Sir David said that the public reaction to the Report indicates great misgivings about doing so now.

Dealing more fully with the question of teachers, which he regards as the heart of the problem, Sir David said that about 18,000 teachers would be needed to raise the school-leaving age; but before we can spare these teachers, we must reduce the number of over-size classes and so give the teachers in them the chance of doing their job really well. No other single reform, in his opinion, would so raise the standard of education in Britain. Four factors have postponed the removal of this handicap to good teaching: the unexpected increases in the birth-rate; the very welcome increase in numbers of those voluntarily staying at school beyond the age of fifteen; a considerably greater wastage of teachers than was expected; and the introduction of the three-year training course for teachers in place of the two-year course. This last reform, the only factor under Government control, involves the loss in 1962 of more than 10,000 new teachers coming from the training colleges, and because of it, while agreeing with the Crowther Committee that one or at most two leaving dates during the year would be sound educationally, Sir David said that because of the employment implications, he would be discussing that aspect with the Minister of Labour and others concerned before reporting to the House the Government's conclusions.

As regards the actual supply of teachers, Sir David Eccles said that the output of teachers from the 39,000 places in the training colleges could not exceed 13,000 a year if over-crowding is to be avoided and reasonable provision reserved for overseas students. The Government has accepted in principle the

recommendation in the Crowther Report to add a further 8,000 places, but Sir David could not say how soon this could be achieved; if all went well, he thought by 1970 that over-size classes could be eliminated and at the same time the school-leaving age raised. Dealing next with the introduction of county colleges, he said that the Government agrees with the Crowther Committee that the raising of the school-leaving age should come first for three basic reasons stated in its Report. Nevertheless, the Government intends to press on with the voluntary further education of the sixteen- and seventeen-year-olds, and he believes that the technical college programme, which has progressed so much in the past three or four years, provides the opportunities for a big advance. First, the 300 local colleges, well spaced in England and Wales, a few of which are already running courses of the county college type, form a natural focus for the development of county college work. Secondly, as the Parliamentary Secretary to the Ministry, Mr. K. Thompson, said in replying on the debate, the Ministry has plans for much-improved arrangements for courses in technical colleges to expand further education on a voluntary basis. Some 400 projects have been authorized for the establishment of new colleges or the improvement of existing colleges.

Sir David did not refer to one important point made in the Crowther Report regarding the staff of the sixth form in schools—the fact that the schools have not yet experienced anything like the full effects of the decline in the quality of recruitment in recent years, nor did other speakers in the debate refer to the serious risk of a still worse crisis in science-teaching as the older men and women retire. Besides, however, touching on the question of finance, Sir David concluded by emphasizing two other important matters, both of which were also stressed by Lord Hailsham. As regards finance, Sir David estimates that, making no allowance for any of the Crowther recommendations, the annual cost of education for England and Wales would have risen from the present £700 million by one half by the end of the decade, and by four-fifths in the middle 1970's. Nevertheless, the Government believes it right to find this £1,400 or £1,500 million a year for education, even if it means sacrifices in other directions.

The first of Sir David's two points is that of educational research. The Crowther Committee commented that the present expenditure on educational research, in view of the large annual expenditure on education, can only be regarded as pitiable, and that if there is to be a consistent programme of educational development, almost the first step should be to review the provision for statistics and research. Sir David had referred to some specific examples where more information is needed before stating that action is already being taken to increase the amount of such research undertaken by the Ministry and to strengthen its statistical services; this action was warmly welcomed by several speakers in the debate, notably Mr. I. J. Pitman, Mr. F. Blackburn and Sir Hubert Ashton.

Lord Hailsham did not touch on this question of research in his speech in the House of Lords on March 23, but generally he followed the line taken by Sir David Eccles. Even more explicitly, he gave first priority to the elimination of over-size classes, which he thought should be possible by the end of the present decade; and in referring to the plans for more teachers, he urged that the number of graduates among teachers should be substantially increased. He also referred particularly to the provision of graduate teachers of science and mathematics. To maintain 1959 staffing standards in 1970, we shall need to increase the present 12,800 graduates in science by about 400 a year net, and ideally we should at least double the average net annual increase; though Lord Hailsham does not think we are likely to achieve this even with the proposed expansion of the universities and a significant contribution from the training colleges, where a number of specialist science wings have been attached to general colleges with a capacity of about 1,200 places. The four hundred science specialists expected from these wings should provide an invaluable supply of teachers to the schools, especially those with General Certificate of Education 'Ordinary' Level courses which at present employ 3,250 non-graduate science teachers. In March 1959 there were 5,100 mathematics graduates and 7,700 science graduates teaching senior pupils in maintained schools; but at the end of 1958 there were 505 such posts vacant and another 509 were said to be unsatisfactorily filled.

On finance, Lord Hailsham reiterated his view that we should spend at least 5 per cent of the gross national product on education. He also pointed out that even without the 8,000 additional places in teacher-training colleges, the cost of education in Britain will rise to £1,000 million by 1964, and with university education will then be more than 5 per cent of the estimated gross national product. He reminded the House that education will be in competition with claims on the national income from roads, railways, pensions and National Health Service, for example, and that it is imperative that investment in factories, transport, machinery and laboratories should keep pace with educational advance. He admitted that it is a great weakness in the educational system of Britain that so many children go out of full-time education at fifteen, but he emphasized the importance of first making sure that the curriculum is suitable to the needs of those who are thus compelled to remain at school.

Apart from a passing reference at this point to the county colleges and the experiment proceeding in some local colleges of further education, the most important remaining passages in Lord Hailsham's speech were those which took up the comment in the Crowther Report on the absence of any single body within the United Kingdom which looks at school and university education as a whole, and in which he urged that the schools and universities should come closer together. Sir David Eccles had already touched on this in referring to university entrance and to the

helpful response he had had from the Committee of Vice-Chancellors and Principals, who, he said, are fully alive to the need for more university places to be available and the conditions of entrance to be modified to enable sixth-form teachers to find time to teach English thoroughly, and to provide more science for the arts specialists and more of the arts to the scientists.

On the question of university places, Sir David said that the University Grants Committee has already been authorized to discuss with the universities a further expansion of 35,000 to 40,000 places by about 1970 over and above the present target of 135,000 to be available by the late 1960's. Lord Hailsham commented that not long ago strong exception would have been taken to the Minister of Education showing such interest in the universities. He welcomed the change, and what Sir David had affirmed that these problems of university entrance, over-specialization and reform of the curriculum are now being vigorously attacked in concert by the universities, the schools and the Ministry. During the debate, Lord James of Rusholme urged that the raising of the school age is not so much a question of an extra school year as of an opportunity to provide a genuine course of secondary education, and has also both the importance of sixth-form work and the danger of over-emphasizing the gulf between science and human knowledge. In replying on the debate, Lord Hailsham dealt with what is probably the most vital issue in regard to the fixing of a date for raising the school-leaving age. He did not dispute the value of this step or deny the plea for timing which Lord James had reiterated. Conceding, however, the Crowther Committee's conclusion that the necessary measures should be worked out and adopted as a coherent, properly phased development programme, extending over as much as twenty years, it remains true, as Lord Hailsham pointed out, that we are dealing with parents and children who do not share that view as to the value of education after the age of fifteen. It is not simply a question of buildings and the supply of teachers or the development of appropriate curriculum, but of at what stage and in what circumstances we are to apply the principle of compulsion not only to laggards but also to a minority of children whose formal education might well have ceased at fourteen or even earlier.

There is, of course, a further point implicit in a speech of Mr. C. Curran in the House of Commons debate, in which he urged the raising of the school-leaving age to sixteen on the grounds of the social value of taking children of fifteen off the labour market as soon as we can, so as to deny the purchasing power largely responsible for many juvenile problems. From both aspects this question of an additional school year is related to the problem of leisure and to the development of youth services, and it should be clear that any phased programme of educational development in Britain must take account in its timing and other aspects of what is being done to meet the needs of youth generally and to deal with the problems of leisure. That much was indeed recognized by the Albemarle Committee itself; but Sir Geoffrey Crowther, in a speech in Manchester on March 22, challenged the idea of absolute priorities, and with regard to county colleges pressed the need for considerable experience before we commit ourselves to compulsory attendance. It may well be that ultimately the broad advance for which the Albemarle Report calls, and a generous return for the money expended on the youth service, will result from the effect of educational progress generally; it will also depend on the creation of an appropriate public opinion and the impetus given to the supply of teachers and youth leaders of high quality and clear vision and the professional ability to use to the full the opportunities which are now opening to them.

MANAGEMENT OF RESEARCH PERSONNEL

The Human Element in Research Management
By Dr. B. E. Noltingk. Pp. vii+91. (Amsterdam: Elsevier Publishing Company; London: D. Van Nostrand Company, Ltd., 1959.) 9*s*. 6*d*.

I FOUND the title of this book somewhat misleading. It is really a book about research personnel management, rather than about the more restricted conception of the use of the word 'human'. It has chapters on scientists themselves, anatomy of a laboratory, physiology of a laboratory, seniors, juniors, strategy, output and ethics, but does not, for example, deal at any great length with the hopes and aspirations of research scientists, and does not attempt to analyse their motivations.

Despite the author's rather disarming statement in his preface of what "prompts me to the conceit of writing a book without many years' opportunities to put all its precepts into practice", I was left with the feeling that some greater experience on the part of the author and a deeper study of the existing literature on his subject might, when coupled with his own views, have produced a book of deeper significance. For example, the author gives some reasons for not having made himself familiar with all the published work in his field before venturing into print, but the works to which he does refer are, in the main, articles in journals the main interests of which lie in somewhat different directions, and which are summaries rather than the results of systematic observation and investigation.

I am, perhaps, somewhat biased on this matter because I am writing this review in the United States, where there is a considerable literature on Dr. Noltingk's subject. Much that has been written in the United States on this subject might never have achieved publication in Great Britain, but for all that the subject has received considerable systematic study, and the author should, I think, have shown that he was aware of this. This does not mean that on the whole I disagree with the author's views, but they are rather naïve, and because his experience would appear to have been rather limited, he has not produced anything particularly novel.

The book is well written, and the biblical quotations at the chapter headings are apt. Dr. Noltingk does well, in my view, to stress greatly the importance of

asking the right questions concerning research. Most of his generalized conclusions would be agreed by many research scientists who have had to give at least part of their attention to the organization and control of the work of others.

Some of the author's statements are, however, not in accord with past experience. For example, in dealing with the problem of the older scientist he states that if such an individual's project has perforce to be stopped, moving him outside the laboratory may well be the soundest policy. He then makes the common error of suggesting that perhaps laboratory administration is a good outlet for him. He goes on to say that "it is doubtful whether a deficiency of several years' experience could ever be remedied to fit him for the role of a senior scientist in a different field". For many scientists this may be true, but certainly for many more it is true that they can enter entirely new fields effectively and successfully, and experience during the Second World War showed that scientists could do first-class research in disciplines entirely different from those in which all their previous experience lay. I am one of those who believe that very few scientists are dedicated, in the sense that they can do effective work only in one field. I know from experience that some people with first-class paper qualifications will probably never do any effective original work in any field, but for the great majority of scientists I believe that a good man will be good in whatever he tackles.

In dealing with salaries, the author suggests that a time might arrive when "the man in authority could sometimes actually be paid less than those under him". This position has existed for many years in many large research organizations, if one accepts 'under' as meaning 'organizationally under'. In many research organizations in Great Britain and in the United States there are two avenues of promotion, one organizational and the other depending purely on scientific ability with no significant organizational responsibilities. The 'special merit' promotions in the Scientific Civil Service in Britain and the wide use of 'consultants' in the United States are examples of this.

In dealing with periodical reviews of staff for promotion, the author comes to the conclusion that "the simple solution of leaving him to be assessed by the boss, who will apportion accordingly the money he has available, is the best". This is a system which may work in a small organization, but concerning which there are very great difficulties where large numbers of staff have to be considered. Various bosses have various standards, and in any organization, if good staff relations are to be maintained, there must be reasonably common standards throughout it. Some systemization must therefore be attempted unless all the staff can be judged by one individual, and even then my experience is that the majority of junior staff dislike such a system. They feel that their careers depend too much on the whim of an individual, and that whether they get promotion or not may be almost fortuitous. The larger the organization the more this appears to be felt, and it is often not realized that in large organizations, such as the Civil Service, much of the apparent 'red tape', and even much of the apparent inflexibility, derives not from the wishes of the top people, but from the pressures from below. The era of 'the boss can't be wrong' has passed, and although all matters of advancement must to a great extent be the result of subjective assessment by others, modern systems can reduce considerably the element of chance.

In dealing with what he calls the physiology of the laboratory, Dr. Noltingk comes to the conclusion that it should not have a larger staff than about 300 if it is truly to be directed by one man. He thinks that if it is larger than this, then the divisional heads will become virtually directors of separate units. This is probably true, although there are many examples of larger organizations being directed by one man if the organization has grown up under him. On the other hand, it is a little doubtful whether one man can become director of an existing laboratory, even of the 300 size, and be effectively the director of the science as well as the director of the institution, but here much will depend on the nature—not the discipline—of the work. Very much larger organizations can be directed by one man if they are what the Americans call 'uni-purpose', that is to say if they have a convergent structure, and this is particularly the case when the scientific work is applied rather than fundamental. The size of the organization which can be directed by one man becomes much less when the organization is multi-purpose or divergent, that is to say where there is no close relationship between the objectives of the various subjects studied.

In one matter I cannot agree with Dr. Noltingk. In several chapters in the book he mentions the need for a laboratory to advertize its existence: for example, in one chapter he says, ". . . for research laboratories in the modern world, like detergents or beer, need to keep themselves in the public eye not so much by reasoned argument of their excellence as by frequent reminders of their existence". In a further chapter on output he again says about a laboratory, "A proportion of its activities should quite openly and admittedly be devoted to blowing its own trumpet, and betterment of the regard in which it is held should be recognized as part of its desired output".

Something of this sort may be necessary in the organization of which a laboratory is part, but I would have thought that the general principle of 'good wine needs no bush' applies very much to scientific research establishments. If they do good work they will become well known, and however large they are and whatever their publicity policy, unless they do good work their reputation will suffer. I particularly, therefore, disagree with the author when he says of a laboratory director, ". . . the need to approach problems scientifically should be, with the praises of his own laboratory, the twin stanzas of his signature tune".

E. S. Hiscocks

MAYA HIEROGLYPHICS

Maya Hieroglyphic Writing

An introduction. By J. Eric S. Thompson. Second edition. Pp. xxii+347+64 figures. (Norman, Oklahoma: University of Oklahoma Press, 1960.) 10 dollars.

WHEN this book first appeared in 1950 as one of the publications of the Carnegie Institution of Washington it was thought that it was only for specialists, but it was written with such a background of knowledge of the Maya, both those who survive and those long dead, that it has had a far wider appeal. It has been out of print for some time and

the demand for it has proved so great that this new edition has been issued by the University of Oklahoma Press. Apart from a short preface reviewing progress since 1950, it is a facsimile reproduction of the first edition, with the welcome addition of a substantial binding. Experience has shown that a word of explanation about the title of this massive work will not come amiss; far from being a mere introduction to Maya hieroglyphics, it is a very profound study of this difficult subject, but it was also designed to introduce a dictionary of non-calendrical glyphs, a work which the author has only just finished. Eric Thompson has studied the Maya for the past thirty years or so, and has long been known as one of the foremost authorities on their hieroglyphic writing. This book has added greatly to his reputation.

It contains a wealth of detailed information about the various types of Maya inscription, those cut in wood and stone, and those painted in the manuscripts and to a lesser extent on wall or pot. Each of the great synchronized cycles which make up the calendar is considered, and new light is thrown on divinatory inscriptions. All this reveals the staggering complexity of the subject; but the treatment is lightened by the author's constant insistence on human and spiritual factors and by the happiness of his style. He says in effect that mathematics and astronomy have an essential part in this study, but that an understanding of Maya religion and mythology is as important, and he goes so far as to say that "Mysticism, religion and poetry completely dominate their hieroglyphic writing." It is emphasized that the whole of Maya religion revolved around the majestic conception of the eternal march of time, in which the periods into which the calendar is divided are borne along by the gods, who pause only to change their burdens over like relay runners at the appropriate period endings. This is graphically shown on the most elaborate form of inscription, the full-figure glyphs exemplified by Stela *D* at Copan, of which a free modern version forms the frontispiece.

The brevity of this notice is not a measure of the importance of the book, which is unsurpassed in its own field, but of the small number of those who concern themselves with the study of the Maya in Great Britain. It is pleasant to record that the author himself has returned to swell their number after living for many years in the New World, and it is to be hoped that his new Glyphic Dictionary will soon be published.

G. H. S. Bushnell

WORLD DISTRIBUTION OF ABO BLOOD GROUPS

The ABO Blood Groups

Comprehensive Tables and Maps of World Distribution. By Dr. A. E. Mourant, Ada C. Kopeć and Kazimiera Domaniewska-Sobczak. (Occasional Publication No. 13 of the Royal Anthropological Institute.) Pp. viii+276. (Oxford: Blackwell Scientific Publications; Springfield, Ill.: Charles C. Thomas, Publisher, 1958.) 42*s*. net.

DR. MOURANT and his colleagues have brought together all the results published up to the end of 1957 on the frequency of the ABO blood groups in the human population; the figures are given for the majority of areas in the world. The result is a most comprehensive book on the distribution of these groups incorporating 1,056 references and 6 maps.

After a short introduction, the information is given in the form of tables. These show place, population, authors and numbers of samples examined, the frequencies of each of the groups, the calculated gene-frequency and, in the last column, the figure D/σ. The vast bulk of the material has been published in the form of the groups O, A, B, and AB, but there are sections where the sub-groups of A have been wholly, or partially, classified. The authors say that "the classification adopted for the data is primarily topographical"; both place and population are well covered, and the population column includes racial or tribal names where appropriate.

In the largest section of the work, the gene-frequencies have been calculated according to Bernstein's formula, but in the section where the sub-groups of A are completely classified the maximum likelihood method is used. The figure D/σ in the last column is given in preference to the usual χ^2; it is a measure of the deficiency or excess of the group AB in the results as compared with the calculated frequency. The authors consider that this value allows the reader to make his own estimate of the reliability of the results with respect to genetical homogeneity or accuracy of testing. It is unfortunate that the authors did not write a more comprehensive introduction, giving details of the statistical calculations and more details of the factors which affect the value of D/σ, with a discourse upon the interpretation of the results; for the average reader this would have been most helpful. The claim of the authors that this single figure gives a general indication of the reliability of the results is probably valid, but others might well have need to consult the original paper to obtain an accurate estimate of a particular work.

The book is an excellent reference book, with good typography. It is easy to read and the tables are set out (and the book opened) in the long way, which makes them easy to see; but the book is not so easy to fit into a bookcase. To have all this information available in such a small compass is, indeed, valuable for all who are concerned with blood groups, whether they are hæmatologists, anthropologists or geneticists. Dr. Mourant and his colleagues are to be congratulated on the production of this extremely comprehensive and unique work.

F. Stratton

FACTORS AND CAUSES OF INFECTIVE DISEASES

The Aetiology of Infective Diseases

With Special Reference to the Subsidiary and Important Non-specific Factors. By Prof. Reginald Lovell. Pp. viii+136. (London: Angus and Robertson, Ltd., 1958.) 27*s*. 6*d*.

IN this book Prof. Lovell, whose experience and authority are well known, gives us the substance of lectures which he delivered in the Department of Microbiology and Public Health at Michigan State University in 1955. He intends the book to stimulate rather than to instruct, and hopes it will awaken interest in the philosophy of epidemiology; both of the aims are certainly achieved. Much knowledge of fact is also added in the author's clear and persuasive style. Though the text refers largely to diseases of domesticated and other animals, the relationship between these and the diseases of man is well brought out.

The book begins by pointing out that the nature of disease is always changing and that this constant change is part of our social history. An infective disease, once it is established, Prof. Lovell reminds us, may stay with us for good and he gives us evidence of this. Discussing next the normal bacterial flora of man and other animals, and the phenomena of resistance (immunity) to disease, he goes on to discuss the host-parasite relationship, which, like disease, is never stable, a fact which is, in spite of Lovell's view to the contrary, very well realized nowadays.

In Part 2 of the book the author discusses various subsidiary factors which play a part in infective disease. Thus the influence of age is illustrated by reference to white scours of calves, infantile diarrhœa, lamb dysentery, Johne's disease of cattle, meningitis in children, diphtheria, scarlet fever, leptospiral infections and various viral diseases, including poliomyelitis. The significance of sex is illustrated by reference to mastitis and pyelonephritis of cattle, trichomoniasis, tuberculosis, brucellosis and other infections. The effects of changes in the host's diet are illustrated by reference to botulism, food poisoning by *Salmonella*, enterotoxæmia of lambs and protein deficiencies and those due to changes in husbandry and environment, by tuberculosis, the slow pneumonia of sheep in Iceland called 'maedi' and by Johne's disease of cattle and braxy of sheep. Fungal infections are considered under the heading of the effects of the general health of the host. In an interesting section on the effects of trauma the author discusses tetanus, gas gangrene and infections with various species of *Clostridium* and those due to the bites of animals, such as rabies. The effects of stress and fatigue and the use of properdin and adrenocorticoids for the treatment of them are then considered, and a final section discusses infections which involve a living vector as well as a pathogen, the diseases here discussed including rickettsial and viral infections, influenza of man and swine, louping ill, foot and mouth disease, yellow fever, psittacosis, *Q* fever, distemper of dogs and the different distemper of cats and other infections. A brief bibliography gives references to standard works.

Both the veterinarian and the student of human disease will learn much from this book, and it will, as its author commendably intends, make him discard any tendency he may have to think of each disease as a separate entity.

G. LAPAGE

A TREATISE ON STATICALLY INDETERMINATE STRUCTURES

Hyperstatic Structures

An Introduction to the Theory of Statically Indeterminate Structures, Vol. 1. By Prof. J. A. L. Matheson. With chapters by Dr. N. W. Murray and Dr. R. K. Livesley. Pp. xv+4[illegible] (London: Butterworths Scientific Publications, 1959.) 90*s*.

THE student of that branch of elasticity which deals with structural mechanics too often finds himself confused by the numerous 'theorems' and 'principles' which so liberally ornament the literature of the subject. This confusion is worse confounded by the use of various names for the same result, and even, on occasion, the appropriation of a well-established designation for something quite different.

In fact the number of independent principles which are of value to the engineer are surprisingly small, and even if the subject is approached from a purely academic point of view rather than from a more practical one, that number is not greatly increased. Many of the results which are so frequently stated as principles are in fact variations, often obvious ones, of fundamental theorems. These variations may, indeed, prove very useful in particular applications, but their isolation from the fundamentals on which they are based makes for an artificial elaboration of the subject and the consequent bedevilment of the student.

One of the avowed objects of the author of this book is to clarify this position and to show the interrelationship of the many theorems and methods commonly quoted. The result will be of considerable interest to the reader who already has a working knowledge of the subject; but the word 'introduction' in the title may prove somewhat misleading and even disheartening to the real beginner.

In the preface the author says that the book is an attempt to produce the treatise (incidentally a much better description of the work than is indicated by the title) which his friends hoped that the late Prof. Cyril Batho would write. Batho had an extensive knowledge of German literature on theory of structures and a great admiration for the work of Mueller-Breslau in particular, and his friends will be in no doubt that he would have been pleased by Prof. Matheson's treatment. This comment, however, does only partial justice to Matheson; in addition to the careful presentation of the classical work of Clerk Maxwell, Mohr, Castigliano, Williot and Mueller-Breslau there is much which could not have been found in a book by Batho, for even in the few years since his death considerable advances have been made. References to the work of David Williams, E. H. Brown and others in clarifying the relationship between the different energy theorems, and the specialized chapters on the stability of struts and frameworks, and on matrix methods of analysis, by N. W. Murray and R. K. Livesley respectively, indicate the up-to-date character of the book.

In this connexion, too, the inclusion of a short account of the work of Prof. J. F. Baker and his colleagues at Cambridge is to be welcomed as an outline of the latest trends in steel structural design based on collapse loads; the possibility suggested by the author that this reference may be out of place in a work dealing with elastic structures surely need not be considered seriously. Elastic and plastic behaviour are both phenomena with which the engineer has to deal, and any attempt at a complete separation of their study can only lead to an unbalanced outlook.

A suggestion for future editions which might be offered is that the section of Chapter 1 which deals with intuitive methods for the approximate solution of statically indeterminate problems should be relegated to an appendix. It is undoubtedly true that a visualization of displacements can materially assist the analysis of a structure, but it is equally true that intuition can come only as a result of experience and knowledge, and to suggest some of the ideas contained in this section at such an early stage may prove a disservice to the student rather than a help.

The book is excellently produced, and with its companion volume of examples which is promised for a later date will add something distinctive to British literature in theory of structures. One wishes it the success which it merits.

A. J. S. PIPPARD

A Guide-Book to Biochemistry

By Kenneth Harrison. Pp. viii+150. (Cambridge: At the University Press, 1959.) Cloth edition, 17*s*. 6*d*. net; Paper edition, 10*s*. 6*d*. net.

THERE are several good modern biochemistry books in the thousand-page category, but there is a real need for the introductory type of book of a hundred pages or so. Biochemistry has grown into such a vast subject that an author who is courageous enough to write a small book about it is sure to be criticized for what he decides to leave out, if not for what he puts in. The decision will, of course, depend on the type of reader the author has in mind. According to the dust cover (for which the author may not be responsible), this book is aimed not only at science students at the university, but also at boys and girls at school who may be thinking of taking up biochemistry later on. What will these potential biochemists find in the book? After a short introduction they will find chapters on energy, oxidation (including several pages on the *r*H scale), photosynthesis, metabolism of carbohydrates, fats and proteins, and a final chapter on control of metabolism. For good measure they will be able, in an appendix, to study the full structural formulæ of complex molecules such as coenzyme *A* or uroporphyrin-III. But they will find nothing about, say, hæmoglobin and its functions, and, as the author himself says, it is a far cry from the contents of this book to a dog or a cat or even a cabbage. One wonders whether the cry need have been quite so far as it is. No, the value of this book is not so much as an introductory guide to biochemistry for school children or for university students, but as a means of helping students to consolidate and summarize biochemical knowledge which they have gained from their lectures and text-books. Here it will fulfil a most useful purpose. The information, though so highly condensed, is clearly set out and is up to date. The book is well produced, and few misprints were noticed. The price is very moderate, and it was a good idea to make available a paper-backed edition at an even lower price.

D. C. HARRISON

Nuclear Electronics

Proceedings of the International Symposium on Nuclear Electronics organized by the French Society of Radioelectricians. (Sessions 1–5.) Pp. xii+452. (Vienna: International Atomic Energy Agency, 1959.) 84 schillings; 24*s*.; 4 dollars.

THIS volume contains the texts of fifty papers presented by delegates from the European countries and the United States at sessions 1–5 of the symposium on nuclear radiation detectors, associated pulse techniques and reactor control measurements and instrumentation. About a half of the papers are printed in English and the rest in French. A brief record of the discussion periods is given at the end of each of the five sections.

Session 1, on scintillation radiation detectors, includes a general review paper on the characteristics of phosphors and photo-multipliers developed during the past ten years and summarizes the important problems for future investigation. Separate papers deal with fast photo-multiplier tubes and with scintillation processes in phosphors, including variation of phosphor decay-time with specific ionization, and its application in differentiation of particle types. Session 2 is devoted to other types of radiation detectors used mainly in nuclear physics measurements, and includes short papers on ionization counters, scintillation in gases, a gas Cerenkov counter and semi-conductor radiation detectors. Three papers describe developments in gamma-ray spectrometry.

Session 3, on fast pulse techniques, includes a brief review of fast electronics in high-energy physics, and separate papers on trigger circuits, coincidence circuits, timing circuits and pulse generators for use in the nano-second time region. Session 4 on pulse techniques is devoted mainly to pulse-height analysers while Session 5 contains a short review on philosophy of reactor safety control in the United States, and several contributions on control systems and measurements in French reactors.

Much of the information has been published elsewhere in greater detail, but the collected papers will serve as a useful reference book on recent developments to designers and users of nuclear electronic equipment.

W. ABSON

Electromagnetic Radiation from Cylindrical Structures

By James R. Wait. Pp. ix+200. (London and New York: Pergamon Press, 1959.) 50*s*. net.

THE designer of aerials for aircraft and missiles must co-operate with the aerodynamicist and is therefore led to types of aerial which can be mounted on wings or fins without disturbing their aerodynamic properties. A satisfactory form of aerial is the slot, for which the behaviour in an ideal infinite conducting plane is well known. On an aircraft, however, the slot must be mounted on a relatively small conducting surface, which inevitably has an appreciable curvature. There is therefore a need to have information on the influence of curved surfaces on the radiation from slots and also from small dipoles mounted at right angles to the surface. The author of the present book has tackled this problem for those surfaces which admit the possibility of a formal electromagnetic solution. The surfaces include circular and elliptic cylinders, wedges and corner reflectors. In each case a detailed mathematical solution, usually in series form, is derived and comprehensive numerical results are given for the parameters likely to be of practical interest. These numerical results, which are given graphically, can be readily used by the practical designer even if he is not interested in the details of the theory.

The material is clearly presented and should be intelligible to the physics or electrical engineering graduate with a reasonable knowledge of electromagnetic theory. A useful appendix on the classical theory of radiation from current distributions serves as a revision of the fundamental results from which the main text is developed. An excellent feature is the frequent reference by the author to the similarity between radiation and scattering problems, and the reciprocity theorem is used to illustrate this. The volume is thus also of value to those interested in the theory of electromagnetic wave scattering. In particular, the short account of the work of Fock in this field provides an admirable introduction to the many original papers which use Fock's methods.

This book fills a gap in the existing literature and is strongly recommended to those with theoretical interests in aerials and electromagnetic scattering problems.

J. BROWN

USE OF LONG-LIVED NATURAL RADIOACTIVITY AS AN ATMOSPHERIC TRACER

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THE fission product activity in the atmosphere and in rain-water due to nuclear test explosions has been sampled in the United Kingdom and elsewhere for several years[1–3]. Studies of the distribution of some of the long-lived components of this activity, in particular, strontium-90 and cæsium-137, have revealed interesting seasonal variations and latitude distributions which have been interpreted as supporting the Dobson–Brewer model of atmospheric circulation deduced from measurements of ozone and water vapour[3]. Elements produced by cosmic rays have been proposed as possibly fruitful tracers for further studies of atmospheric movements[4].

A common feature of all such tracers, fission products, ozone and isotopes produced by cosmic rays is that their effective source lies in the stratosphere. They can consequently be used directly to study the mechanism of transport of air from stratosphere to troposphere, but not the complementary transport in the opposite direction. It seemed that a useful group of radioactive isotopes for this purpose would be the longer-lived, daughter products of radon—radium-D, -E and -F—which are naturally present in the atmosphere as a result of the leakage of radon from soils and rocks on the Earth's surface.

This article gives the results of an exploratory survey of the distribution of these isotopes in air and in rain-water, derives certain conclusions from these and points to the value of a more comprehensive programme.

Radon Decay Products

Radon is one of the elements formed by the radioactive decay of uranium which is present in greater or lesser degree in rocks and soils all over the world. Being a gas, radon can escape from the Earth's crust into the atmosphere, where it disintegrates radioactively to form a chain of solid daughter products, each of which is produced by the disintegration of the preceding one, the final element being lead, which is stable. The half-lives and radiation characteristics of the decay products are shown in Table 1, where for clarity minor branches of the decay series have been omitted.

Table 1. Radon and its Decay Chain

Chain member	Isotope	Half-life	Radiation
Radon	Radon-222	3·8 day	α
Radium-A	Polonium-218	3·1 min.	α
Radium-B	Lead-214	26·8 min.	$\beta\gamma$
Radium-C	Bismuth-214	19·7 min.	$\beta\gamma$
Radium-C′	Polonium-214	160 μsec.	α
Radium-D	Lead-210	19·4 yr.	$\beta\gamma$
Radium-E	Bismuth-210	5·0 day	β
Radium-F	Polonium-210	138·4 day	α
Radium-G	Lead-206	Stable	—

The daughter products are ultimately washed out of the atmosphere in rain after a mean period of residence in the troposphere of about 20 days (par. 2 of Discussion). The half-lives of the radium-A, -B, -C and -C′ are short compared with this mean residence time, and these isotopes are generally found to be in secular equilibrium with each other and with the parent radon[5]. Since radium-D takes some 80 years to reach equilibrium with radon, it is removed from the atmosphere by rain long before this state can be reached. Thus, typical values of the concentration of radon over land and sea are 200 d.p.m./kgm. (disintegrations per min. per kilogram of air) and 4 d.p.m./kgm., respectively[6], but the mean value of the radium-D concentration at ground-level reported by Blifford is only 0·03 d.p.m./kgm.[7]. For the same reason it is to be expected that the radium-E concentration will be less than that of radium-D, and radium-F less than radium-E. The low concentration of all these isotopes makes it necessary to pass large volumes of air through filters in order to obtain samples large enough for analysis, and complications can result from the collection of soot and other airborne dusts which may interfere with subsequent chemical separations.

Sampling Procedures

Air sampling programme. Ground-level air samples were collected at a height of 1 m. above the grass airfield at Harwell using cylindrical filters of esparto grass paper through which about 6,000 kgm. of air were passed at a mean linear speed of 140 cm./sec. during a normal 24-hr. period[1]. Above ground-level the samples were collected on filters attached to aircraft which were flown, primarily to collect fission products, at various fixed altitudes up to 48,000 ft. Some of these samples were obtained on disk filters fitted in a tube which carried an orifice plate for measuring airflow during flight. In general, the amount of air sampled in each such flight was too small for analysis; but by combining and analysing a batch of several filters from the same altitude it was possible to determine mean values of the specific activity at that altitude. On other occasions, a cylindrical filter was flown together with the disk, and the much larger amount of air thus sampled was determined from the ratio of the fission product activities of the two filters and the airflow through the disk. Typical linear sampling velocities were 460 cm./sec. at 18,000 ft. and 350 cm./sec. at 48,000 ft. The filters analysed were collected at various times between 1951 and 1957.

The efficiency of filtration is subject to uncertainty; but this is not considered to be serious. The radon daughter products are created as individual atoms in the decay process, and filtration efficiency is known to be high for such particles[8]. However, it has been demonstrated that the atoms can become attached to condensation nuclei in the atmosphere[9], and in this form filtration efficiency may be lower. Recent measurements made at Harwell[10] have shown that at sampling velocities in the region of 400 cm./sec. the sampling efficiency of esparto paper has a minimum value of 40 per cent for condensation nuclei of diameter 0·06 μ. The efficiency increases rapidly with diameter and has a value of about 70 per cent at 0·08μ. Mobility studies have shown that, when first formed, condensation nuclei have diameters in the region of 0·001μ, but they coagulate rapidly and reach 0·01μ in about 1 hr. and have increased to 0·08μ in about 20 hr. The atmospheric residence-time of daughter product atoms will be shown to be about 20 days, and during this period it is probable that the nuclei to which they are attached are larger than 0·08μ, and that the sampling efficiency is relatively high. A value of 100 per cent has been assumed in this article.

Rain-water sampling programme. Samples of rain-water were collected at Harwell in polythene bottles using two identical polythene funnels each with a 5-cm. rim and a collecting area of 2,000 cm.². Each funnel and storage bottle was cleaned and rinsed with distilled water before sampling began. To eliminate the possible effect of dry deposition on the funnel, the apparatus was only set up when a period of steady rain was beginning and it was taken in as soon as the rain stopped. The samples were acidified with nitric acid, carriers (lead and bismuth) added, and the volume measured before returning the samples to polythene bottles to await evaporation and chemical analysis. By independent analysis of the samples collected in the two units a check could be made on the reproducibility of the subsequent processing of two similar samples. Typical collections provided 2–6 litres of rain-water during a sampling period of a few days.

Chemical Separation Methods

The measurement of small quantities of radium-D, -E and -F in air and rain-water samples is complicated by the presence in the atmosphere of fission products from nuclear test explosions. During the course of the present experiments, the fission product concentration in air was very variable and generally exceeded the radium-D concentration by a factor of 100 at least. Trace-level experiments were carried out with solutions of radium-D, -E, -F and fission products and a complete separation procedure was worked out, based on solvent extraction of the dithizone complexes of lead and bismuth. Full details are given elsewhere[11]. The extracted isotopes were measured using standard low-background Geiger and scintillation counters.

The analytical method extracted at least 80 per cent of the radium-D, -E and -F from the samples and the limit of significant measurement was 2 d.p.m. The radiochemical purity of the separated isotopes was satisfactory, and in test extractions less than 0·01 per cent of the fission product activity initially present remained in the final radium-D fraction. In some cases, radium-D, -E and -F were measured on the same sample, but in most samples the analysis was limited to radium-D and radium-E or to radium-D and radium-F.

Results

Atmospheric concentration of radium-D. The concentration of radium-D in the airborne dust collected on air filters was estimated by two independent methods. In the first method, radium-F analyses were carried out on air filters which had been stored for several years after the dust samples had been collected. During this period the radium-F collected during sampling had almost completely decayed, while fresh radium-F had grown into equilibrium with the radium-D originally collected on the filter. Consequently, the radium-F content of the filters could be used to estimate the amount of radium-D collected by the filter at the time of sampling. In most cases, more than two years had elapsed between sampling and the chemical separation, so that the radium-F was at least 95 per cent of its final equilibrium concentration. In a few cases, the theoretical build-up was only 85 per cent, and a correction was added to the derived radium-D concentration. The results of these measurements are given in Table 2. Where more than one filter is specified in column 3, these were collected at different times during the stated periods but were combined for analysis. The standard deviation (*S.D.*) of each of the values in column 6, due to errors in air flow measurement, chemical analysis and counting, is estimated to be less than ± 15 per cent.

In the second method the samples were stored for about twenty days to allow the radium-E to come into equilibrium with the radium-D, and separate analysis of the two isotopes was carried out. The measured amounts generally agreed to within 20 per cent,

Table 2. Atmospheric Concentration of Radium-D measured by Analysis of Radium-F in Old Air Filters

Air filter sampling details				Air concentration (10^{-3} d.p.m/kgm.)	Average air concentration (10^{-3} d.p.m./kgm.)
Sampling altitude	Collection date	No. of filters	Air mass sampled (kgm.)		
Ground-level	May 1954	1	4,800	7·3	7·0
Ground-level	May 1954	1	5,400	6·7	
11,000 ft.	July–August 1954	3	400	19	21
11,000 ft.	January–February 1955	2	270	22	
27,000 ft.	July–August 1954	5	390	30	
27,000 ft.	September 1954	2	130	30	28
27,000 ft.	January–February 1955	3	220	24	
40,000 ft.	July–August 1954	8	290	37	37
47,000 ft.	June 1955	4	105	55	55
48,000 ft.	January 1955	7	125	74	74

Table 3. Atmospheric Concentration of Radium-D measured by Analysis of Radium-D–Radium-E in Air Filters

Air filter sampling details					
Sampling altitude	Collection date	No. of filters	Air mass sampled (kgm.)	Air concentration (10^{-3} d.p.m./kgm.)	Average air concentration (10^{-3} d.p.m./kgm.)
Ground-level	August 1954	1	6,000	6·7	
Ground-level	August 1954	1	18,300	6·0	
Ground-level	January 1955	1	5,900	8·5	
Ground-level	January 1956	1	5,300	6·4	
Ground-level	August 1956	1	6,000	3·2	7·1
Ground-level	November 1956	1	15,600	7·4	
Ground-level	December 1956	1	5,500	13	
Ground-level	January 1957	1	5,500	5·5	
11,000 ft.	July–August 1954	5	670	12	
11,000 ft.	January–February 1955	10	1,360	17	17
11,000 ft.	January–February 1955	11	1,470	23	
18,000 ft.	August–November 1955	11	1,330	18	
18,000 ft.	August–November 1955	11	1,150	22	18
18,000 ft.	January–February 1956	8	760	14	
27,000 ft.	July–September 1954	10	740	19	
27,000 ft.	August 1956	1	250	36	29
27,000 ft.	August 1956	2	350	32	
30,000 ft.	July 1956	1	730	32	32
30,000 ft.	July 1956	1	680	31	
35,000 ft.	September 1956	3	1,530	34	34
45,000 ft.	July–January 1955	19	520	50	50
47,000 ft.	July 1956	1	130	70	70

which is consistent with the estimated *S.D.* of ± 10 per cent on each individual determination. The results of these analyses are given in Table 3.

The averaged concentrations of radium-D determined by both methods are plotted against the altitude of sampling in Fig. 1 to give the vertical distribution of radium-D. The numbers in parentheses adjacent to each point refer to the number of separate samples used. It is clear that the two methods of measurement are in good agreement and that it is possible to draw a smooth curve through the experimental points. This agreement provides a measure of confidence in the sampling, separation and averaging procedures and suggests that the number of samples, although small, is adequate. There is, however, a systematic error inherent in the sampling procedure for radium-D arising from the fact that the filter paper collects the short-lived radon daughter products from the air, and these afterwards decay to form more radium-D on the paper after collection. This error is likely to be greatest at ground-level, where the concentration of radon is highest, but it can be shown to be small. Gale[5] has found that the mean concentration of radium-A, -B and -C in ground-level air at Harwell is 115 d.p.m./kgm. Collected on a filter paper, this would give rise to an apparent concentration of radium-D of $1·2 \times 10^{-4}$ d.p.m./kgm., which is less than 2 per cent of the observed mean value of $7·1 \times 10^{-3}$ d.p.m./kgm.

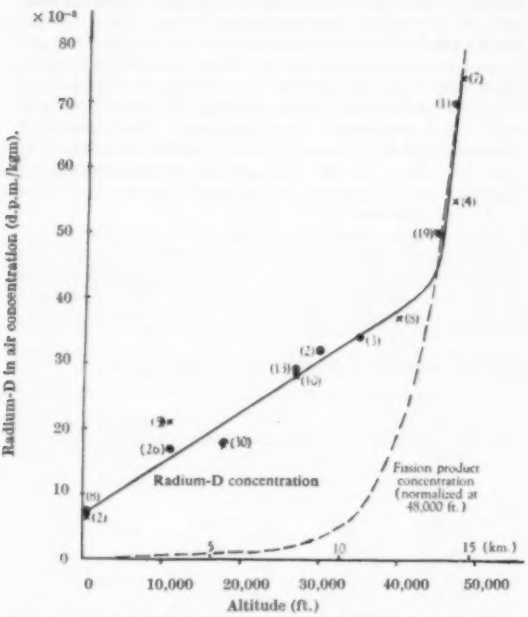

Fig. 1. Vertical concentration gradient of radium-D and fission products in the atmosphere above the United Kingdom. ○, radium-D from radium-D analysis; ×, radium-D from radium-F analysis. Numbers in brackets denote number of filters analysed

Atmospheric concentration of radium-F. Some analyses of radium-F were carried out on recently flown filters in which the measured radium-F concentration was practically the same as existed in the air during the sampling period. In a few cases the time-interval between sampling and analysis was long enough for the radium-F concentration to be affected, and in these cases a small correction was applied. The results of these measurements are shown in Table 4. The samples are grouped so as to average the radium-F concentration at three mean heights: ground-level, 27,000 ft. and 45,000 ft. The lack of data makes the form of the radium-F concentration curve uncertain, but it is clear that the concentration varies from a low value at ground-level to a high value in the lower stratosphere. The actual weighted mean values are $0·9 \times 10^{-3}$ d.p.m./kgm. at ground-level and 30×10^{-3} d.p.m./kgm. at a weighted mean height of 45,000 ft. By comparing these values with those for radium-D in Fig. 1 it will be seen that the ratio of radium-F to radium-D is 0·13 at ground-level, increasing to 0·65 at 45,000 ft. This ratio in the lower stratosphere was also measured using a filter through which a large but unmeasured amount of air had been passed. The observed ratio of radium-F to radium-D in this case was 0·60, which is in good

Table 4. Atmospheric Concentration of Radium-F measured by Analysis of Radium-F in New Air Filters

Air filter sampling details				Air concentration (10^{-3} d.p.m./kgm.)	Average air concentration (10^{-3} d.p.m./kgm.)
Sampling altitude	Collection date	No. of filters	Air mass sampled (kgm.)		
Ground-level	May 1955	1	5,400	0·2	
Ground-level	November 1956	1	15,600	1·0	0·9
Ground-level	December 1956	1	5,500	1·4	
Ground level	January 1957	1	5,500	1·0	
27,000 ft.	August 1956	2	350	11	7
27,000 ft.	December 1956	1	190	4	
40,000 ft.	December 1956	1	70	35	
40,000 ft.	December 1956	1	56	29	30
47,000 ft.	October 1956	3	260	25	
47,000 ft.	December 1956	1	73	31	

agreement with the mean value of 0·65 determined above.

Concentration of radium-D and -F in rain-water. Each rain-water sample was analysed for both radium-D and -F and the results are given in Table 5. On two occasions duplicate chemical analyses were carried out on samples obtained from adjacent collectors. In one case the results agreed to within ± 10 per cent and in the second case to ± 20 per cent, but the radium-F to radium-D ratios in each pair were in excellent agreement. The specific radium-D activity is seen to vary substantially from day to day, but the mean value of 5 d.p.m./litre over the period September–December 1956 is in good agreement with Blifford's value of 5·3 d.p.m./litre observed in Washington, D.C.[7]. The mean radium-F : radium-D ratio of 0·10 in the same period agrees with the ratio of 0·13 found in air at ground-level. This is to be expected since rain collects its dust from the lowest layers of the atmosphere.

Discussion

Radium-D in the stratosphere. The first striking feature of the results is that the concentration of radium-D in the atmosphere above the United Kingdom increases with height above ground and that the gradient increases sharply in the vicinity of the tropopause (Fig. 1). A similar discontinuity has been observed in the gradient of fission product dust from the thermonuclear explosions in Eniwetok in 1954 in which the dust clouds were injected high into the stratosphere[1]. A feature of the distribution of these fission products was that the stratospheric gradient had, within experimental error, the same value some 6 months, 12 months and 18 months after the explosions and this appeared to be a characteristic of the descending cloud. A normalized version of the fission product distribution curve is shown in Fig. 1. It will be noted that the stratospheric gradient of radium-D is very similar to the characteristic fission product gradient. This suggests that in the middle latitudes, where sampling was carried out, radium-D is descending from the stratosphere in a manner similar to the fission products. One possible source of this radium-D is in meteoric and volcanic dusts, which are known to diffuse into the troposphere from high altitudes. However, an approximate calculation indicates that the maximum contribution from these sources cannot account for more than about one millionth of the observed radium-D. We conclude that the radium-D has its origin in the tropopause and has entered the stratosphere at some earlier stage of its history.

Important features of the exchange processes between the stratosphere and the troposphere have been revealed by the work of Dobson and Brewer on the ozone and water vapour content of the atmosphere and a model of the general circulation based on their deductions is shown in Fig. 2. Dobson[12] explained the observed seasonal variations in total ozone by suggesting that the cold pool of air which forms above the winter pole when it is in shadow ultimately sinks and carries ozone-rich air to the lower levels of the stratosphere. In order to explain the form of the water-vapour curve in the stratosphere, Brewer[13] has suggested the circulation system shown in the model in which tropospheric air enters the stratosphere near the equator, travels to temperate and high latitudes and then sinks into the troposphere again. Fission product studies have supported this model. Thus, it has been shown that the rate at which fission products re-enter the troposphere from the stratosphere varies in the same seasonal manner as the total ozone[2]. Again, the concentration of fission products in air and in rain-water has a pronounced minimum in equatorial regions and a peak in the middle latitudes of the northern hemisphere, suggesting that this is where

Table 5. Analysis of Radium-D and -F in Rain-water

Rainwater sampling details			Radium-F activity (d.p.m./litre)	Radium-D activity (d.p.m./litre)	Ratio radium-F/radium-D
Collection date	Sample volume (litres)	Details			
September 27–28, 1956	2·4	duplicate samples	0·58	4·6	0·13
September 27–28, 1956	2·4	duplicate samples	0·42	3·1	0·13
October 1–2, 1956	6·0		0·62	9·3	0·07
October 17–19, 1956	4·0		0·45	6·5	0·07
November 8–9, 1956	4·0		—	6·2	—
December 10–14, 1956	4·3	duplicate samples	0·63	1·7	0·37
December 10–14, 1956	4·3	duplicate samples	0·50	1·4	0·36
December 14–16, 1956	5·6		0·43	2·4	0·18
	Average values		0·51	5·0	0·10

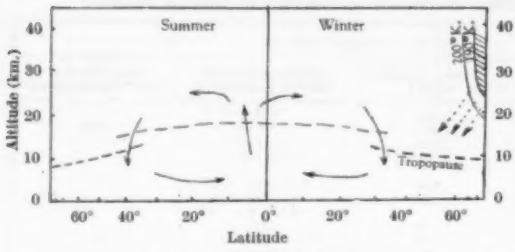

Fig. 2. Atmospheric circulation model (Dobson and Brewer)

the descending fission products re-enter the troposphere.

If this model is accepted, then the source of the radium-D in the stratosphere is the ascending air at the equator, which carries with it not only radium-D but also radon and its daughter products from which more radium-D will be formed.

Radium-D in the troposphere. The radium-D in the troposphere is a combination of two components, one of which is the radium-D descending from the stratosphere while the other is radium-D which was created and has remained in the troposphere. If we assume that the stratospheric component behaves similarly to fission products, then Fig. 1 shows that the tropospheric component predominates and that this component increases with height. At first sight this is surprising since the parent radon is known to originate at ground-level. The explanation is that the radium-D in the troposphere above the United Kingdom is characteristic of Atlantic air and is largely independent of any radium-D formed locally. In its passage across the Atlantic, the parent radon can diffuse above the rain-producing layer in the troposphere into a region where the radium-D formed is not subjected to washout. Radium-D at lower levels is subject to washout and the overall effect is to produce a positive concentration gradient in the troposphere.

It is possible from the results obtained to derive two independent estimates of the mean life of a radium-D atom in the troposphere. First, we can compare the radium-D content of a vertical column of air with the mean rate at which radium-D is deposited by rain. From Fig. 1 the radium-D content of 1 m.^{2} column reaching from ground-level to the tropopause at 40,000 ft. is 167 d.p.m. The mean radium-D content of rainwater is 5 d.p.m./litre, so that an average rainfall of 2 mm./day (characteristic of the middle latitudes of the northern hemisphere[14]) deposits 10 d.p.m./m.^{2}/day. This points to a mean life of 17 days, a figure which would be proportionately higher if the efficiency of air sampling were less than the 100 per cent assumed.

A second rough estimate can be obtained from the ratio of radium-F to -D in the activity deposited in rain-water. If we make the reasonable assumption that the radium-D, -E and -F particles are washed out with equal efficiency by rain, then it can be shown that the radium-F to -D activity ratio is given by the expression :

$$\frac{\text{radium-F}}{\text{radium-D}} = \frac{T^2}{(Te + T)(Tf + T)} \qquad (1)$$

where Te = radioactive mean life of radium-E = 7·2 days ; Tf = radioactive mean life of radium-F = 200 days ; T = mean residence time of an individual atom in the atmosphere.

The mean ratio in the bulked rain-water collected was 0·10 and substitution in equation (1) gives $T = 29$ days. This figure, however, represents the mean residence time of the combined tropospheric and stratospheric components, and since the latter has been airborne for a longer time, it is high for the tropospheric component alone. Thus, if we assume that rain-water removes the activity from a mean height of 6,000 ft., then using Fig. 1 and the observed value of the radium-F/radium-D ratio in the stratospheric component, it can be calculated that the radium-F/radium-D ratio in the tropospheric component of rain-water is 0·075. This gives a value of $T = 22$ days for the mean residence time of those atoms the whole airborne life of which is spent in the troposphere.

Since each radon atom ultimately produces a radium-D atom, a final check on the consistency of the results can be made by comparing the amount of radon exhaled from the ground into the atmosphere with the amount of radium-D deposited by rain. Israël[6] has summarized the radon measurements made in many parts of the world and has shown that the mean rate of exhalation of radon from the Earth's surface, measured directly, is $7·7 \times 10^4$ d.p.m./m.^{2}/day, while the value derived from the measured concentration of radon in the atmosphere is $7·2 \times 10^4$ d.p.m./m.^{2}/day. Since land occupies 39·3 per cent of the surface of the northern hemisphere, we may take a mean radon exhalation-rate of $2·8 \times 10^4$ d.p.m./m.^{2}/day. This is equivalent to a production-rate of 15 d.p.m./m.^{2}/day of radium-D, which is in reasonable agreement with the measured deposition-rate of 10 d.p.m./m.^{2}/day computed above for a mean rainfall of 2 mm./day.

Circulation time of air entering the stratosphere from the troposphere. The ascending equatorial air shown in the model in Fig. 2 will carry with it radon, radium-D and -F together with the other less-important radon daughter products. Since the mean rainfall-rate is higher at low latitudes than in the middle latitudes it is possible that the radium-F will be even more deficient with respect to radium-D than it was in the troposphere above the United Kingdom. When the air enters the stratosphere, it becomes insulated from washout processes, and the radium-F can begin to build up towards its 'equilibrium' value with respect to radium-D, and consequently the radium-F : radium-D ratio in any mass of stratospheric air can be used as a measure of the length of time the air has been in the stratosphere. In particular, by comparing the ratio in equatorial air with that in air in the lower stratosphere above the United Kingdom the period of the circulation process depicted in Fig. 2 can be determined.

One unknown is the composition of equatorial air, but this does not have a major influence on the estimate. If the ascending air contained radium-D alone, then the observed radium-F : radium-D ratio of 0·65 at 45,000 ft. above the United Kingdom would correspond to a circulation time of 212 days. If pure radon was the original constituent, the time would be a little longer. These are upper-limit estimates and are highly unlikely in practice. Another assumption to make is that the ascending air has the same isotopic composition as the air near ground-level in the United Kingdom. This leads to an estimated circulation time of 177 days, which would be low if the radium-F : radium-D ratio in the equatorial troposphere were less than that in the middle latitudes. The true figure should be between these extremes

and the best estimate is therefore of the order of six months.

Suggestions for Further Work

The radium-D, -E, -F measurements have been interpreted in terms of an atmospheric circulation model which appears to fit the facts. Other interpretations are possible, however, and future studies might be directed towards discriminating between the possibilities. L. Machta[15] has pointed out that the steep gradient in the stratosphere could be explained by an extension of the argument in par. 2 of the Discussion, which accounted for the positive gradient in the troposphere. In this 'diffusion' model, the source of the radium-D in the stratosphere is the radon and its daughters which diffuse through the tropopause into the stratosphere and afterwards decay into radium-D. The difference in gradient is due to differences in the diffusion constants appropriate to troposphere and stratosphere. This explanation would appear to require a greater value of the stratospheric diffusion constant than has hitherto been considered reasonable, but the matter might be settled by measuring the radon content of the lower stratosphere to establish if there was enough there to support this hypothesis. It would also be instructive to investigate the concentration of radium-D in the stratosphere in more detail than was possible here, to determine if it was subject to the seasonal variations observed with ozone and with fission products.

Conclusion

The development of a radiochemical separation procedure has enabled a preliminary study to be made of the distribution of radium-D and radium-F in the atmosphere. Systematic results have been obtained which suggest that radium-D is a valuable natural tracer for the further study of atmospheric processes.

The work described in this article was carried out in the Health Physics Division at the Atomic Energy Research Establishment, Harwell; we thank the Director of the Establishment for permission to publish this communication, and also the Royal Air Force for the collection of the airborne dust samples.

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FUEL CELLS: WILL THEY SOON BECOME A MAJOR SOURCE OF ELECTRICAL ENERGY?*

By F. T. BACON
Marshalls Flying School, Cambridge

THE efficiency of all heat engines, that is to say, engines in which heat is converted into mechanical work, is governed by Carnot's cycle; this means that the efficiency is limited in practice by the difference in the temperature at which the heat is taken in by the working fluid and the temperature at which it is rejected. It is the possibility of avoiding the Carnot limitation which constitutes the main, but not the only, reason for interest in fuel cells.

Present-day Fuel Cells

A fuel cell can be defined as an electrochemical cell in which the free energy of combustion of a fuel is converted directly into electrical energy. Gaseous fuels are very convenient for use in electrochemical cells, and either oxygen or air is used as the oxidant. There are various ways of classifying the different types of fuel cell that are now being tried, but it is convenient to divide them up into those working at atmospheric temperature up to, say, 100° C.; those working at a medium temperature, around 200° C.; and those working at a high temperature, say 550° C., and upwards, with electrolytes of fused salts.

* Substance of a Royal Institution Discourse delivered on February 12.

Those which work at a low temperature must, as a general rule, have electrodes with a very large internal surface if reasonably large current densities are to be attained; this is usually achieved by using highly porous materials, either porous carbon or porous metals. Porous carbon is peculiarly suitable for the purpose, and surfaces as large as 200 sq. m. per gm. are commonly used. The activity of the electrodes is often further increased by impregnation with catalytically active materials. The electrolyte in low-temperature cells usually consists of a strong aqueous solution of an alkali such as potassium hydroxide, which has a good conductivity. Work is proceeding in the United States on a rather different type of cell which has an ion-exchange membrane as electrolyte; the internal resistance of this type of cell is liable to be rather high, and the figures for performance which have been published so far are rather low; but, on the other hand, if the electrolyte is of the acidic type, ordinary untreated air containing carbon dioxide can be employed without any danger of carbonating the electrolyte. It can be safely said that the best results in low-temperature cells have so far been obtained with pure hydrogen and oxygen, as might be expected.

Cells which work at a high temperature use a mixture of fused salts, usually carbonates, as electro-

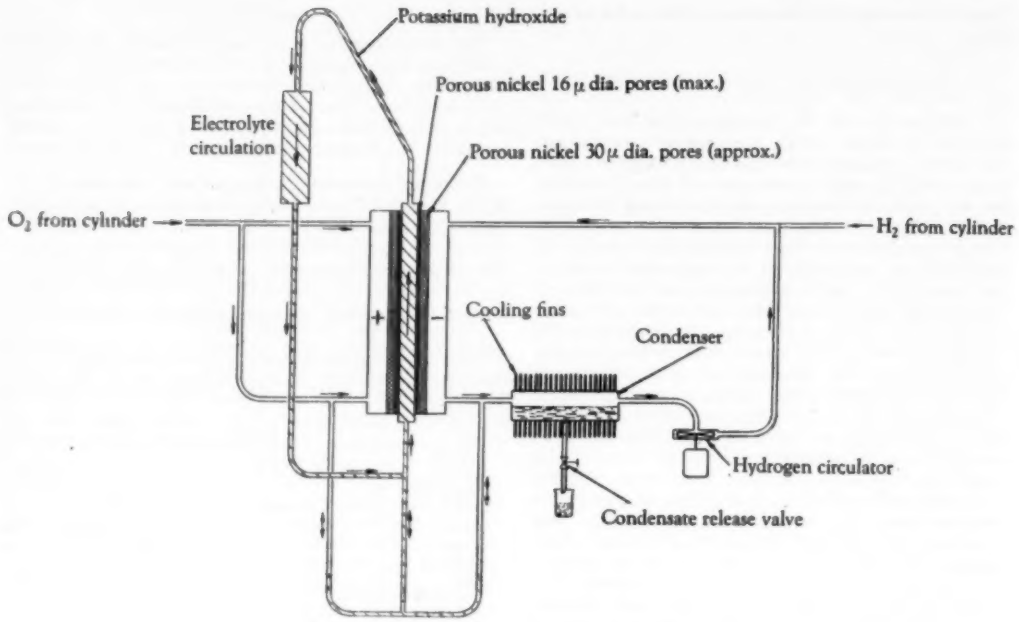

Fig. 1. Hydrogen – oxygen cell

lyte, and this is often contained in a porous diaphragm of sintered magnesium oxide. The electrodes may be of some metal or metal oxide, which must, of course, be kept in close contact with the porous diaphragm. This kind of cell may operate from about 550° up to, say, 800° C., but difficulties with corrosion become greater as the temperature is raised ; the pressure is atmospheric. The great advantage of high-temperature cells is that they will consume impure industrial gases, or vaporized hydrocarbons such as kerosene, and air ; this is, of course, a fundamental advantage in a genuine fuel cell—it uses cheap and readily available fuels.

The reacting gases in medium-temperature cells are usually hydrogen and oxygen ; the theoretical efficiency at atmospheric temperature and pressure is about 83 per cent (based on the total heat of the reaction), and practical efficiencies of about 55 per cent have been obtained at 200° C. and a pressure of 400 lb./sq. in. Work on the high-pressure hydrogen/oxygen cell is now being financed by the National Research Development Corporation.

The electrodes of porous sintered nickel are about one-sixteenth of an inch thick, or less, and the electrolyte is strong potassium hydroxide solution. Fig. 1 shows the arrangement adopted in 1949 and which is still virtually unchanged.

The electrodes are made with a pore size of about 30 microns on the gas side and with a thin layer of much smaller pores on the liquid side ; a small pressure difference is set up in the apparatus across each electrode, so that the liquid is expelled from the large pores on the gas side, but the gas cannot bubble through the small pores on the liquid side owing to the surface tension of the liquid. The interior of the 30-micron pores presents a large surface for absorption of gas.

Thus, in a porous metal electrode of this kind, the current density is kept low by the large internal surface of the large pores, and the gas side of the electrode is kept substantially dry, an essential condition for good performance.

The oxygen electrodes are first impregnated with mixed nitrates of nickel and lithium ; they are then dried and roasted in air at about 700° C. ; in this way they are coated with a conducting oxide layer which is very resistant to corrosion in the cell. Oxygen electrodes treated in this way have lasted for 1,500 hr. in the cell at 200° C. with a drop in output of less than 4 per cent.

The present 10-in. diameter electrodes are not strong enough to be self-supporting against the pressure difference, so they are sintered directly on to solid plates of nickel or nickel-plated steel, which have a large number of holes drilled or punched through them so that gas can readily get through from the other side. Fig. 2 shows the best cell characteristic so far obtained with this size of electrode, and

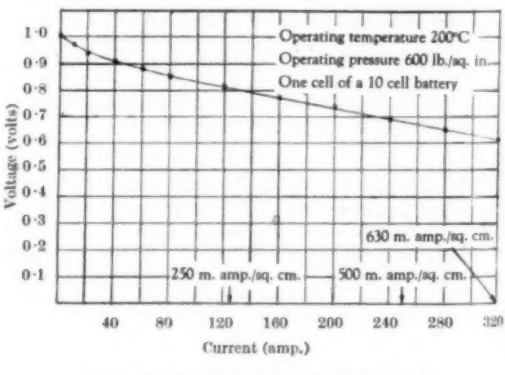

Fig. 2. Best result for 10-in. cell obtained so far

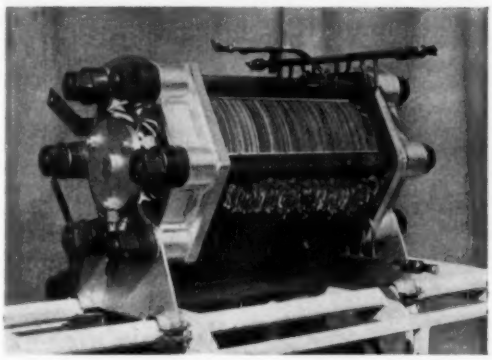

Fig. 3

it will be seen that currents as large as 320 amp. have been achieved.

Longitudinal ports are provided for feeding the two gases and the electrolyte to each individual cell. If bipolar electrodes can be made, a great saving in space and weight will be obtained.

Fig. 3 shows the largest battery built up so far; it has 40 cells, giving an open-circuit voltage of about 40; this gave a performance of 100 amp. at 32 V., or 3·2 kW., and 240 amp. at 24 V., 5¾ kW.

Advantages and Disadvantages of Fuel Cells

It is quite plain that if a fuel cell can be produced which will accept ordinary fuels such as coal, oil or gas, and atmospheric air, a vast field of application is open to it, on both a large and a small scale. Unfortunately, coal must be ruled out, as there is no sign of any cell which can make direct use of it; so we are left with oil in its various forms which can easily be vaporized if necessary, and gas which may be made from coal. Both oil and gas could be considered for large- and medium-scale generation, especially where natural gas is available; and the piping of natural gas over really long distances is now being considered. For large-scale generation, oxygen would probably be too expensive, so air would have to be used. A pressure cell would seem out of the question, owing to the cost of compression, so it seems fairly certain that a high-temperature cell with a fused salt as electrolyte is the answer in this case. Direct current is, of course, generated, so large-scale inversion would have to be considered, unless the device is used for, say, a locomotive, where direct current is desirable.

But the cell on which there is a great deal of controversy at present is the hydrogen/oxygen cell. If it can be brought to the stage of practical application, is it going to be any use in practice? The objections raised are mainly that pure hydrogen is an expensive fuel and is difficult to store; and the oxygen must be carried, too, and this is more expensive than air, which is free. Further, there is no highly developed distribution system, equivalent to that for petrol or diesel fuel. These are important arguments and must be faced.

It is usually agreed that the hydrogen/oxygen cell is essentially a storage device, rather than a genuine fuel cell using a primary fuel, and furthermore, it will be used mainly for road and rail traction. This means that the two gases will be produced by the electrolysis of water, probably in a separate apparatus. Thus the existing electricity grid would provide the distribution system for the fuel, electricity; and the gases would be generated locally. The battery would, of course, produce direct current, which is convenient for driving a vehicle. Considerable developments have taken place in recent years in the field of high-pressure electrolysers, and this should have the effect of reducing the cost of production of compressed hydrogen and oxygen in course of time.

Then there is the further interesting possibility that this particular cell could be made reversible, although it is not fully reversible yet; this should be a great advantage on any vehicle which has to start and stop repeatedly.

It must be admitted that gases are intrinsically difficult to store because they require heavy and bulky gas cylinders; it is tempting to consider storing them as liquids at a low temperature, and in this respect oxygen does not present much difficulty. But hydrogen is much more difficult, and although liquid hydrogen is made in quantities as great as 7 tons per day in the United States for use in rockets, it is still rather expensive. So, in the meantime, we are driven back to gas cylinders.

But the advantages of silence, freedom from fumes and vibration, and very few moving parts, should not be overlooked, and in certain special applications could be important. Further, it is well known that the torque characteristics of a direct-current motor are far better than those of an internal combustion engine which has to rely on a clutch and gearbox for starting. It seems that the hydrogen/oxygen cell is essentially a high-performance device, and therefore inherently suitable for traction.

One further point is that, as more nuclear power stations are built, it will become even more important to look for some method of storing electricity; it is well known that the main proportion of the cost of electricity produced in this way is due to the capital cost of the plant rather than the amount of nuclear fuel used, so that little is saved by shutting them down during time of light load. The present suggestion is that the electrolysers should be kept running at all times, except during the peak-load period, and that the gas produced should be used for driving some of our road and rail vehicles as and when required.

Practical Demonstrations

It is scarcely necessary to discuss applications for fuel cells, as these are fairly obvious if all the technical difficulties can be overcome, and the cost is not too great. The applications for a cell consuming either natural gas or liquid hydrocarbons and air would be enormous, both for static and mobile plant, and the great oil companies have started research work on the problem.

Practical demonstrations have already been given of fuel cells in use. A battery of hydrogen/oxygen cells developing 1 kW. was demonstrated in the United States about two years ago, as a power unit for a mobile radar set used by the U.S. army; it is known as the *Silent Sentry*, and in this case silence was its great virtue.

A demonstration took place at Cambridge in August 1959 of the high-pressure hydrogen/oxygen cell, in which a 40-cell battery was shown operating a small circular saw, providing power for arc-welding, and operating a fork-lift truck. The maximum power was about 6 kW.

A demonstration was given in the United States in October 1959 of a farm tractor driven by a battery of fuel cells supplied with propane and other gases (probably hydrogen) and oxygen. It has 1,008 cells in series and works at quite a low temperature; no details were given of the construction of the cells, but the electrodes must be very active catalytically to be able to make use of propane at a low temperature. 15 kW. is developed. This is the first time that a vehicle has been demonstrated propelled by a fuel cell-battery mounted on the vehicle. This is a great achievement, though the makers are careful to add that it is still a research vehicle.

Conclusion

Why is it that there is so much interest in the United States, and more recently in Germany, in fuel cells, and there is still so little in Britain, though this was where most of the original work was done? Part of the great effort in the United States is no doubt sponsored by the Federal Government, as there are certain military applications where fuel cells would be very valuable; and there is the vast satellite and space vehicle programme, where batteries are used extensively for providing auxiliary power. This is not the whole story, however, as some large companies are putting their own money too into research on fuel cells. It seems that the explanation is that the idea has 'caught on' in the United States, whereas in Britain it has not, as yet; and in any event, American firms are prepared to set aside enormous sums of money for research and development, even on comparatively speculative devices such as fuel cells.

It is, of course, known that the world reserves of coal, oil and natural gas are very great, but we are using them up faster now than ever before; the fuel reserves in Great Britain are not great, in comparison, and practically all oil has to be imported. Surely attention should be given to any device which might show an economy in the use of fuel. Part of the purpose of the vast atomic energy scheme in Britain was to help to conserve dwindling coal supplies; if a small part of the effort devoted to atomic energy could be given to a study of fuel cells in all their possible forms, an answer would probably be obtained within a very few years.

PRELIMINARY FLIGHT TESTS OF AN ATOMIC CLOCK IN PREPARATION OF LONG-RANGE CLOCK SYNCHRONIZATION EXPERIMENTS

By FRIEDRICH H. REDER and GERNOT M. R. WINKLER
U.S. Army Signal Research and Development Laboratory, Fort Monmouth, New Jersey

THE performance of atomic and molecular frequency standards has been the subject of intense studies for several years[1-3]. In particular, tests have been made with a commercial cæsium beam frequency standard[4] ('Atomichron') under various environmental conditions. The 'Atomichron' employs a crystal oscillator which is continuously servo-controlled with respect to a microwave resonance of cæsium atoms. Usually the 'Atomichron' is employed to calibrate and check, at regular intervals, the rate of precision crystal clocks. It can, however, also be operated to drive a clock directly (within the life-time of the cæsium beam tube, which may be better than 6,000 hr.). Irregularities in time as small as one μsec. after 100 hr. have been achieved[5] during laboratory operation of the clocks in a controlled-temperature environment and with a stabilized power source. As an extension of these tests, flight experiments have been carried out with an operating atomic clock of the type mentioned above in preparation for a large-scale clock-synchronization project[6] aiming at an error of less than 1 μsec. between clocks separated by more than 1,000 miles. It is the purpose of this article to describe briefly the preliminary flight experiment and its results.

One atomic clock was operated from a voltage regulator in an air-conditioned laboratory room. The other clock was mounted in a *DC*-3 aircraft. All measurements were done in the laboratory by utilizing a microwave link between laboratory and airport, which are separated by a distance of 10 km. Both one-sec. pulses and the 100-kc./s. output signal were used to measure rate and time difference between the two clocks (Fig. 1). To ensure the least effect of Coriolis forces upon the atoms in the

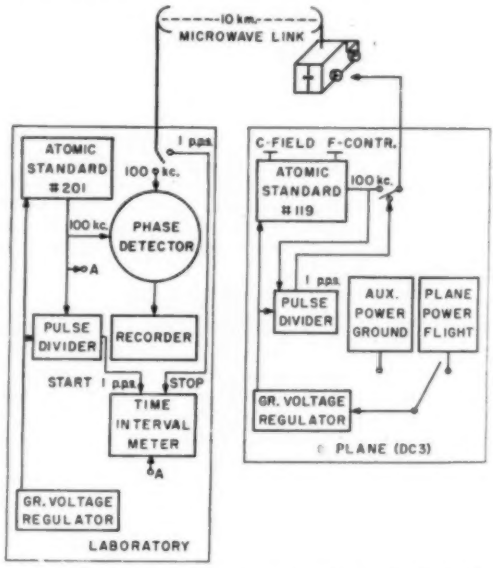

Fig. 1. Block diagram of measurement equipment for the flight test

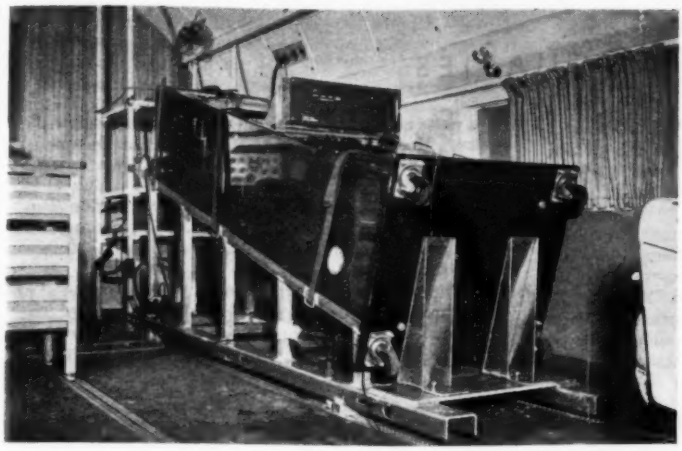

Fig. 2. Position of atomic frequency standard in the aeroplane. Off-standing chassis contains the crystal oscillator on shock mounts

beam tube during flight, the plane clock was operated in an almost horizontal position (Fig. 2). While the aeroplane was on the ground, power for the equipment was furnished by a petrol generator mounted in the tail of the plane. Shortly before take-off, power was switched to the main board supply, with the line voltage input to the atomic clock being held constant by a buffer battery and a voltage regulator.

The aeroplane was unpressurized and without temperature control. However, the temperature was kept manually between 15° and 22° C. The flight altitude was about 330 m. above sea-level due to a very low ceiling.

One ½-hr. flight was made on November 16, 1959, and a 1-hr. flight on November 17. The pilots were instructed to turn not faster than about one complete turn per minute to avoid Coriolis effects. Despite considerable vibrations in the plane and rather unfavourable weather conditions on the second day, performance of the transported clock was quite astonishing (Figs. 3 and 4).

The uncertainty of time determination (after correction for the small rate of the clock) was less than 60 nanosec. after the shorter and smoother flight, and less than 150 nanosec. after the longer and rougher flight, which was plagued by a very short power failure caused by a faulty switching operation before take-off. It can be seen from Fig. 4 that this power failure resulted in a short-time perturbation of the relative rate of the two clocks. The results lead us to believe that synchronization of remote clocks by means of a shuttle plane is entirely feasible, and that, even with existing equipment, such synchronization will be about a thousand times more accurate than that at present possible through use of radio time signals.

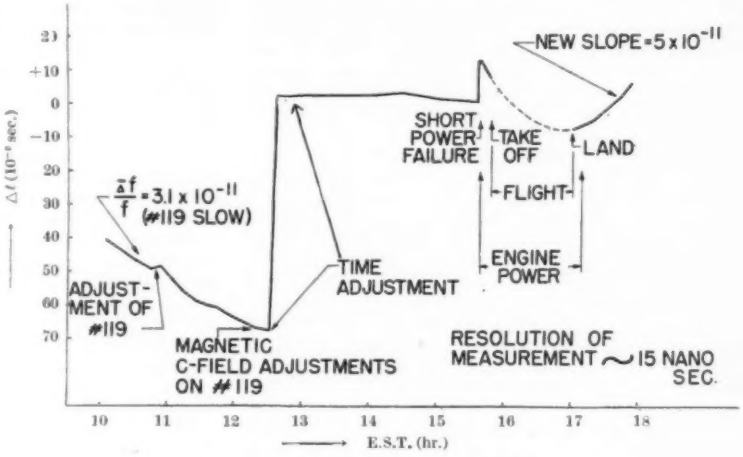

Fig. 4. Results of the second (1 hr.) flight test

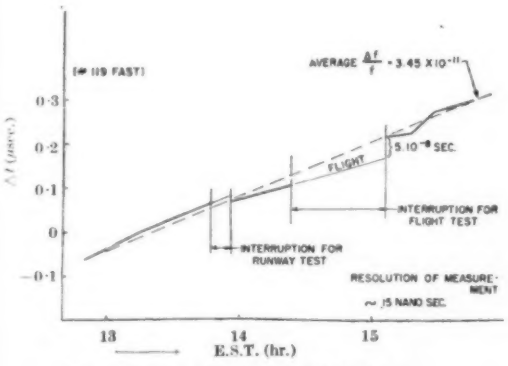

Fig. 3. Results of the first (½ hr.) flight test

Further extensive tests on synchronization of widely separated atomic clocks are in progress and will be reported soon.

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OBITUARIES

Dr. Roy Chapman Andrews

Dr. Roy Chapman Andrews, famous for his Gobi Desert discoveries in the early 1920's, died in New York early in March. He was seventy-six. He was born at Beloit, Wisconsin, on January 26, 1884, and was educated at the comparatively small College there, graduating A.B. in 1906. He then proceeded to Columbia, where he took his A.M. degree in 1913. He also had some experience in the Museum of Comparative Zoology at Harvard. His later education was interrupted by his absences on expeditions, those forays and excursions, often with important scientific and geographical results, that were to be the main interest of his life and the foundations of his undoubted eminence.

His association with the American Museum of Natural History began in 1908 when he joined an expedition to Alaska; he did exploration work on the St. Lawrence in 1909, shortly afterwards becoming naturalist in the U.S.S. *Albatross*, which visited the Dutch East Indies and Borneo in 1909–10. During 1911 and 1912 he was in Korea and in 1913 he was back in Alaska. These were, however, but preludes to his main task, which came when, in 1916, he was appointed leader of the American Museum expeditions to Central Asia. From 1917 until 1931 he was intermittently in Mongolia and in China in pursuit of vertebrate fossils and the remains of man.

His chief, the distinguished director of the Museum, Prof. Henry Fairfield Osborn, held the theory that the likely area of the dispersal of mammals and of man was to be found in the Orient, and the expedition's results, if not exactly convincing for this theory, were encouraging in the considerable materials that they produced. Dinosaurs and dinosaurs' eggs earned the expedition fame, though the dinosaurs were not so important as many that had already been found, and dinosaurs' eggs had been discovered earlier in England and in France. Andrews also found small Cretaceous mammals and giant Tertiary mammals and mastodons, but not a scrap of the fossil man he was working for, though *Sinanthropus* was later to turn up not so very far from the house where he kept palæontological court in Pekin.

Judged by any standards, Andrews's Asiatic expeditions were a success, and resulted in considerable additions to many museums other than his own, for the American Museum was generous, and excellent representatives of the dinosaurs from the expeditions are in the British Museum (Natural History).

Scientific and other honours rightly came to him. He was made Sc.D. of both his native Beloit and of Brown University, Rhode Island. He also received many medals, mainly for the geographical aspect of his work, from the National Geographic Society and the Explorers' Club in his own country, and from the national geographical societies of Sweden and Hungary.

During 1931–35 Andrews was vice-director in charge of exploration and research at the American Museum of Natural History, and from 1935 until 1942 he was director. He retired in 1942 with the title of honorary director.

He was the author of ten books and many scientific papers. Most of these were written in his beautiful homes in Connecticut or in California, where successively he lived after his retirement. But they were far from being his only interests. The Boy Scout movement and many sports, mostly connected with horses, engaged his attention, and he was always a hospitable man.

His name will be remembered in the annals of vertebrate palæontology and in the history of the distinguished Museum he served so well for so long.

W. E. Swinton

Mr. C. A. Shain

Charles Alexander Shain, an outstanding member of the radio astronomy group at the Commonwealth Scientific and Industrial Research Organization (Australia) Radiophysics Laboratory in Sydney, died on February 11 at the early age of thirty-eight. His contribution to radio astronomy lay in the frequency-range around 20 Mc./s. where he pioneered the study of the two features peculiar to this range of radio astronomy: absorption in ionized interstellar hydrogen (H II regions), and absorption and refraction in the ionosphere. Observations in this frequency-range are particularly difficult owing to interference from radio stations and the complicating effects of the ionosphere; but they give unique information of great importance to radio astronomy. Shain's work is basic in this field.

Shain studied physics in the University of Melbourne and graduated in 1942. He immediately entered the second Australian Imperial Force, but was discharged on medical grounds late in 1943. He then joined the staff of the Radiophysics Laboratory, where he stayed until his death. During the remaining stages of the War, he worked on radar counter-measures, and from 1945 on various aspects of decametre-wave radio astronomy.

His work in radio astronomy began with a study of Moon echoes at a frequency of 20 Mc./s. This work, which was an immediate follow-up of the pioneering American and Hungarian experiments, led to the recognition of the dual causes of the fading of Moon echoes: libration of the Moon and propagation effects in the ionosphere. Using parts of the same equipment, he then began the observations of the distribution over the sky of relatively low-frequency (20-Mc./s.) cosmic radio waves which he continued until his death. He first used broadside arrays, the largest of which consisted of 30 half-wave dipoles and had a beam-width of 17°, and then a 'Mills cross' with arms 3,500 ft. long and a resolution of 1·4°.

In the first phase of these investigations he was able to show conclusively that the brightness distribution over the Milky Way at this frequency was markedly influenced by absorption in H II regions; but he had insufficient angular resolution to delineate even the largest of these regions, and his 'Mills cross' was designed to overcome this limitation. At the time of his death he had nearly completed a 19-Mc./s. map of the greater part of the Milky Way, which shows numerous examples of the obscuring

regions which he sought. His colleagues plan to complete and publish this unique and important work as soon as practicable.

In this frequency-range, the absorption of cosmic radio-waves in passing through the ionosphere is often appreciable and the interpretation of cosmic observations requires a knowledge of absorption in the various ionospheric layers. Shain's pioneering work on such absorption, particularly interesting at the time of solar flares, sufficed for his own purposes and has since given rise to a vigorous branch of ionospheric research which follows the inverse approach and uses observations of the absorption of cosmic radio waves to obtain information about phenomena in the ionosphere.

A by-product of the cosmic radio wave studies concerns radio emission from Jupiter. Following the discovery in the United States in 1956 of emission from this planet in the 20-Mc./s. range, Shain examined his old records. He found a large number of extended bursts of emission, which had previously been attributed to terrestrial interference, but which could now be identified with reasonable certainty as due to emission from Jupiter. Examination of the times of occurrence of these bursts showed a remarkable correlation with the rotation period of Jupiter, indicating that the emission originated in a very few active areas on the planet which remained in fixed positions for long periods.

Alex. Shain was a wonderful colleague in the laboratory—imaginative, well balanced, exceedingly unselfish, and a real friend to all. In his home community he was a leader in Church affairs. In murra where he lived he was, among other things, the Anglican Church in the Sydney suburb of Turra-Sunday school superintendent, lay reader and the leader of a Bible Study Group. He was a man who exemplified the principles of Christianity in all his dealings with men.

J. L. PAWSEY

Mr. K. J. F. Park

THE death of Kenneth John Frederick Park in a drowning accident on March 2 at the age of thirty-two has robbed the Nature Conservancy of a most valued officer, science of a first-rate ecologist and the world of a man of rare quality.

Park was educated at the Royal Grammar School, Newcastle upon Tyne, and at King's College, Newcastle. Between school and college he served three years in the Royal Air Force, and this took him to the Middle East and gave width of experience to an alert mind. He left the University with a first-class degree in botany and a good knowledge of the arctic-alpine vegetation of northern England, the Scottish Highlands and the Hebrides. His interest in field botany led him to postgraduate work on the ecology of Upper Teesdale, particularly the sugar-limestone outcrops. This work was interrupted in 1954 by his appointment as officer-in-charge of the Nature Conservancy's Moor House Field Station more than 1,800 ft. above sea-level in the northern Pennines.

His basic scientific interest was the conservation of upland Britain, using the word conservation in a wide and humanitarian sense. His own research was focused on the potential productivity of the grasslands on mineral soils. He aimed to get quantitative data on long-term trends in fertility-levels, as determined by grazing, leaching, soil weathering and other factors causing gain or loss of nutrients. During the past year or two he had been attacking these problems directly, for example by observations on rates of leaching, but before this he had put in much intensive work on recording the existing state of the various grassland types on the Nature Reserve. He did this by setting up a series of sheep exclosures and using various methods of mapping, point-quadrat recording, and detailed photography of vegetation. The methods were not of course original, but the standard of accuracy and the finish of the work are altogether outstanding and are witnessed in the volumes of the Nature Reserve Record Book. The plots have been laid out and recorded as the firm starting-point for observations visualized as going on over a century or more.

Over and above his own research line, he built up an impressive collection of information about the Reserve and the surrounding countryside, and himself contributed many superb photographs.

When he went to the Field Station he had nothing to work on but rather sketchy possibilities; but in his six years of imaginative and efficient management, he created a live centre of scientific work in remote and difficult conditions, where visiting workers could come and use their time productively. His achievement was due not only to his very hard work and exceptionally high standards but even more to his personal qualities, which enlisted the co-operation of anyone who came into contact with him, and the devoted loyalty of all his colleagues, both senior and junior.

Dr. Paul Haas

PAUL HAAS, who died on April 6 at Cheam, was born in 1877, the son of distinguished parents. His father was professor of Sanscrit at University College, London, and his mother was a gifted pianist who, before her marriage, had a European reputation as a soloist. Even in her old age, Madam Haas played the music of Bach in a manner few could equal, and her son inherited musical appreciation.

Paul Haas was educated at University College School when it was in Gower Street, then at University College, and he studied also both at Freiburg and Geneva. As an investigator, he was very deliberate and conscientious. With the late Prof. T. G. Hill, he collaborated in the investigation of the biochemistry of seaweeds and the chromogens of *Mercurialis perennis*, and they produced, in 1913, "An Introduction to the Chemistry of Plant Products", which was afterwards extended into a two-volume work.

It was in teaching, however, that Haas found his chief interests, and his lectures and demonstrations were always carefully prepared. He lectured on organic chemistry both at St. Mary's and St. Thomas's Hospital Medical Schools, and also at the Royal Botanic Gardens, Kew, until he became reader in plant chemistry at University College, of which he was a Fellow.

Paul Haas had a retiring kindly personality with a quiet sense of humour. He looked after his mother devotedly, at their home in Westbourne Park, until her death, and his colleagues had regarded him as a confirmed bachelor. But romance came to him when inspecting schools for the University of London, and at the age of sixty-one he married Beryl Grace Wood who, with a son of the marriage, survives him.

E. J. SALISBURY

Prof. J. A. Hanley

The death of Prof. J. A. Hanley on April 10 occurred after several years of physical handicap, gallantly borne with the help of his devoted wife, following a breakdown in health he suffered in the post-war years. He has been living during this period of retirement from his academic career in Applethwaite, near Keswick. His last appointment was that of professor of agriculture and rural economy in King's College, University of Durham, Newcastle upon Tyne, where he directed the work of the School of Agriculture and Cockle Park (then Northumberland County Experimental Station, now owned by the College) from 1931 until 1947.

Hanley, who received his school education at Wakefield Grammar School, served later in the county of his birth and forbears as lecturer in agricultural chemistry and advisory chemist in the University of Leeds. Prior to this appointment he had obtained the degree of Ph.D., University of Munich, as well as becoming an associate of the Royal College of Science, for which he studied in London. Before going to Leeds he had been engaged in research at Rothamsted, and was Board of Agriculture Research Scholar during 1912–14. From Leeds he went as professor of agriculture and chief advisory officer in the University of Bristol, where he served from 1924 until 1927, whence he became principal of the Royal Agricultural College at Cirencester, where he continued during 1927–31. His appointment to the chair of agriculture at Newcastle—in succession to the famed Somerville, Middleton and Gilchrist—was made in 1931.

There is no doubt that he experienced much satisfaction from the opportunities afforded him in the scientific directorship of Cockle Park—an office which devolves on the professor of agriculture in King's College—for Hanley's major interest in agriculture was the subject of grassland management. As early as 1927 he was the joint author with Prof. R. G. Stapledon of the book "Grass Land : its Management and Improvement", published by the Oxford University Press, and in subsequent years he was responsible for the Ministry of Agriculture's well-known bulletin on "Grassland", as well as for several of the Ministry's leaflets on various aspects of the same subject. He was a leading spirit in the national campaign for grassland improvement, taking a prominent part as judge and adviser in the grassland competitions organized in the four northern counties of England during the early 'thirties.

While giving much attention to grassland, especially to the then recent developments in its utilization as dried grass and silage, in which subject he carried out early investigations at Cockle Park, Hanley had a wide knowledge of agriculture and agricultural education. In a volume of essays presented to Sir Daniel Hall on "Agriculture of the 20th Century", published in 1939, Hanley's fine contribution was a comprehensive study entitled "Agricultural Education in College and County".

Among his original contributions when at King's College was a survey of agriculture in the Northern Province (Counties Durham, Northumberland, Cumberland and Westmorland), made possible by a financial grant given by the Right Hon. David Lloyd George. Although this was a comparatively quick survey, the report published in 1936 gives an informative account of the agriculture of the area which for the purpose of the survey was divided into twenty districts ; Hanley being assisted in this extensive project by two of his students, Messrs. Boyd and Williamson.

As in the case of his predecessors mentioned in the chair of agriculture, King's College, he formed many mutually helpful friendships with northern farmers—as, for example, D. J. Brown of West Learmouth, and J. B. Barr of Pressen—the study of whose farms, and discussion of changes in management, resulted in his contribution to the *Journal* of the Royal Agricultural Society of England, entitled "Tweedside Farming Enterprises", which itself is a typical example of the wide range of subjects on which he wrote for various journals. In his latter years he was editor of a series of four volumes published by Caxton in November 1949, under the title of "Progressive Farming".

During the Second World War, from 1940 onwards, he became the Ministry of Agriculture's liaison officer for the northern counties in connexion with the food production campaign.

From my personal knowledge as a colleague for the period of his professorship at King's College, I knew him to be a very good teacher, whose courses of lectures on soils and geology are remembered. He showed a greatly appreciated interest in the social and athletic activities of his students, being *inter alia* a keen supporter of their Rugby achievements, to which a photograph (still hanging in the Dean's private room in the School of Agriculture) bears testimony showing him surrounded by members of the team. No one who knew him intimately could fail to be aware of his emphasis on efficiency and his keen interest in his work as a teacher and adviser on agriculture, and of his continuous desire to make his contribution to the progress of that distinctive movement in the present century towards the improvement in management of the grassland of Great Britain.

H. Cecil Pawson

Dr. F. Jones

Dr. Francis Jones, T.D., died suddenly at Crowborough on February 28.

Francis Jones was born at Belper, Derbyshire, in 1887. He was educated at Wirksworth Grammar School, graduated at the University of London, and later took his Ph.D. in geology. He was commissioned as a lieutenant in the Royal Engineers during the First World War and served in France, Gallipoli and Egypt. He taught as a science master, first in Leicester and then from 1929 until 1947 at St. Dunstan's College, London, where he served as commanding officer of the Officers Training Corps for eight years. During this period he also acted as head of the Department of Geology at the Northern Polytechnic. Between 1926 and 1936 he published a number of papers on his researches on the petrology of the Pre-Cambrian rocks of Charnwood Forest.

His love of geology and young people coupled with his tremendous energy would not allow him to retire, and in 1947, at the age of sixty, he joined the staff of the Geology Department of the Imperial College of Science and Technology, where he remained until 1958 ; at the same time he continued until his death his teaching at the Northern Polytechnic. In the lecture theatre and the laboratory he was insistent on fundamentals. Influenced by his great friend, the late Dr. Alfred Brammall, he brought his knowledge of chemistry to bear on theoretical aspects of mineralogy and petrology, and his lectures and discussions on

these topics were a stimulus to all those who were privileged to hear them.

Anxious to use every minute of his day, he turned the accumulated knowledge of his academic career to the problems of engineering geology, and from the age of sixty-one until his death worked during vacations as a consultant geologist on civil engineering projects in Syria, the Lebanon, Iraq, Iran, Ghana, the Sudan and on the Kariba Dam in Central Africa. His kind but rugged features were a true expression of his character. He possessed a physical toughness and endurance which were remarkable for a man of his age. Twenty miles a day on foot in the deserts of the Middle East or the bush of Africa left him undaunted; he invariably led the way. His only admission of physical discomfort was at the age of seventy, when he said that he felt somewhat sore after riding on horseback for two days through the Elburz Mountains of Iran.

Loyalty was the keynote of his personal life, and despite the failing health of his last two months he travelled to various parts of the country to fulfil lecture engagements regardless of the advice of his doctor and friends. It was his sense of loyalty supported by his great physical courage which carried him from his home at Crowborough to London to give his last lecture to his students at Northern Polytechnic ten days before he died.

D. J. Shearman

Dr. August Gansser-Burckhardt

Dr. August Gansser-Burckhardt, who died on January 27 at his home in Basle, will be remembered by many for his achievements in fields on the borderlines of technology, and by his friends for his radiant personality. He was born in Milan in 1876. After passing the examination in chemistry at the Federal Technical College in Zurich, he obtained a doctorate at the University of Zurich in 1900. After one year's further study in London, Dr. Gansser began his life-long association with the family enterprise, the present S.A. Ledoga in Milan, manufacturers of vegetable tannins and natural dyes. It was at an opportune time, since Dr. Lepetit had just worked out his revolutionary process of making cold-water soluble quebracho extract by sulphitation. Gansser contributed substantially to the success of this venture. Since 1917, he had resided at the old home of his family, Basle, serving as the international co-ordinator for the family concern.

Along with his business activity, two major inquiries became gradually the all-absorbing interests in his life. His name will always be connected with the battle against the warble fly and with his contributions to the ancient history of leather. His fight for the eradication of the warble fly, which not only inflicts sufferings on cattle but also does a great deal of damage, resulting in much decreased value of the hides and impaired yields of milk and meat, made him well known throughout the world. His untiring efforts in this vital crusade were recognized by his Alma Mater by the award of the honorary degree of D.V.M. His second interest was archæology, particularly the study and analysis of finds from excavations of Roman settlements on the Continent and particularly of sites in Italy. His broad humanistic knowledge and his scientific training became a most effective combination in this pioneering research. He handled the archæological issues as well as the chemical analysis of the finds most competently.

Dr. Gansser was the founder of the Swiss Society of Leather Chemists, and he was instrumental in re-establishing international contacts after the two World Wars. At the time of the first one, he served as the president of the International Society of Leather Chemists.

Dr. Gansser was a man of wide culture, embodying the best traditions of his beloved Switzerland and Italy, and of kind and unassuming disposition. His sterling personality and his talents as a linguist and speaker—with five languages ready to his service—made him a well-known, and lately legendary, figure at international gatherings in his field of work for more than half a century.

K. H. Gustavson

Mr. F. H. Edmunds

With the death of Francis Hereward Edmunds on April 19 at Westhumble, Surrey, British practical geology lost an exponent whose work had long been an encouragement to civil engineers and many other professional men seeking advice on geological problems. His friendly guidance will no less be missed by innumerable students, research workers, amateur geologists, naturalists and interested laymen in the south of England. Many will recall with pleasure the field excursions led by Edmunds and the lectures he was always pleased to give to promote popular understanding of the influence and application of geology. Most of all, however, he will be missed by his colleagues on the Geological Survey of Great Britain, where he served from 1922 until 1957 and was always happy to encourage the younger geologist.

Edmunds was proud to own himself a native of Wiltshire. He was born at Mere in 1893 and was educated at Gillingham Grammar School, in the neighbouring county of Dorset. After serving in France as a captain in the Tank Corps during the First World War, he went up to Emmanuel College, Cambridge, where he made many friends in the University. He obtained first-class honours in geology in Part II of the Natural Sciences Tripos in 1922.

Throughout his career on the Geological Survey, Edmunds maintained his strong interest in geological mapping. Large areas on a number of published 1 in. to the mile maps, notably in Surrey, are the result of this work, and Edmunds was part-author of the explanatory memoirs on the Reigate, Guildford and Romford districts. Among other official publications, he was author of "British Regional Geology: The Wealden District" and part-author of "The Central England District" in the same series. Edmunds compiled a memoir on "The Wells and Springs of Sussex", and published papers in the *Journal of the Institution of Water Engineers* and elsewhere. During his period in charge of a small unit formed at the Geological Survey in 1936 on the request of the Inland Water Survey Committee, Edmunds organized the systematic collection and collation of well-records and undertook many advisory duties for Government departments and the Services, particularly during the Second World War. During 1945–57 Edmunds was district geologist for South-Eastern England.

Perhaps the strongest appeal of his book, "Geology and Ourselves", lies in its treatment of aspects of civil engineering and geology in everyday life. Edmunds also wrote and lectured with authority on the geology of scenery, of soils and of building materials. He was president of the South-Eastern Union of Scientific Societies in 1949 and took an

active part in the Geology Section at the British Association meetings of 1954 and 1955.

Among his activities after retiring from the public service, Edmunds continued to put his geological knowledge at the disposal of the community on questions of planning in the County of Surrey.

It is sad that the fatal recurrence of an illness he had suffered three years previously prevented Edmunds from enjoying longer a happy retirement in the beloved Mole valley where he had made his home since 1939. His wife and daughter will know that his memory will long be cherished in the Dorking and Mickleham district for his activities both as townsman and countryman, and the delight he took in music and musical affairs.

S. C. A. Holmes

NEWS and VIEWS

Earth Satellite 1960ε

The heaviest satellite yet to be placed in orbit about the Earth was launched from the U.S.S.R. at about 00 hr. U.T. on May 15. Its total weight, excluding the final stage of the rocket which took it into orbit, is 4,540 kgm. (10,010 lb.), more than three times as heavy as *Sputnik* 3, which was launched two years earlier. The satellite, which has been called *Korabl'-Sputnik* or space-ship satellite, consists of a pressurized cabin weighing about 2,500 kgm., which contains a dummy astronaut and all apparatus necessary to keep a man alive in space, together with extensive instrumentation, weighing about 1,500 kgm. The satellite carries various radio transmitters, with the main one operating on a frequency of 19·995 Mc./s. The chief purpose of the satellite is to test the design of the cabin, and the first measurements made by the instruments suggested that the environment in the cabin was suitable for human survival. It is stated that the cabin is to be detached from the remainder of the satellite; it will then probably burn up in the atmosphere, since it is not designed to withstand re-entry.

The orbit of the satellite, like that of *Sputniks* 1, 2 and 3, is inclined to the equator at an angle near 65°. The initial period of revolution was 91·2 min., corresponding to a semi-major axis of 6,713 km., and the orbit was nearly circular, having an eccentricity of about 0·0048. The satellite was at perigee when going north at a latitude near 54° N., the perigee height being about 320 km. (200 miles) and the apogee height about 380 km. (235 miles). The lifetime of the satellite is uncertain, being dependent on conditions after the separation of the cabin, but does not seem likely to be more than a few months. At latitudes between 40° N. and 60° N. the satellite will be favourably placed for observation in the night sky during May and June. The final stage of the launching rocket separated from the satellite on entering orbit.

Cryptogamic Botany at Manchester: Prof. J. Colhoun

Dr. John Colhoun, reader in mycology and plant pathology in the Queen's University, Belfast, has been appointed to the chair of cryptogamic botany in succession to Prof. C. W. Wardlaw, who now occupies the George Harrison chair of botany in the University. Though his published work lies in the fields of mycology and plant pathology, of which he is a distinguished exponent, Dr. Colhoun is also a botanist of wide experience. He entered the Queen's University of Belfast in 1930, graduated in science in 1933 and in agriculture in the following year. The next four years were spent in research at the Department of Agricultural Botany in Belfast and at the Imperial College of Science and Technology, London. He returned to Belfast in 1938 to the Department of Plant Pathology and from 1940 up to the present has held posts in the Departments of Agricultural Botany and of Mycology and Plant Pathology. Since 1939, he has held, concurrently with his University appointments, corresponding posts in the Plant Pathology Division of the Ministry of Agriculture of Northern Ireland. During 1942–49, Dr. Colhoun was warden of the Queen's Elms hall of residence for men in Belfast and has also held other University posts. During the past twenty-five years Dr. Colhoun's researches have been directly related to fundamental problems in plant pathology, particularly in relation to plant environment, the control of the diseases of economic plants, and the investigation of the physiology of various fungi. He has also co-operated with geneticists in a programme of breeding disease-resistant plants. He is the joint author of a book on "The Diseases of the Flax Plant", the author of an important monograph on "Club Root Disease of Crucifers" and of many contributions to scientific journals.

Physiology at the London Hospital Medical College: Prof. K. W. Cross

Kenneth William Cross, who has been appointed to the chair of physiology in the London Hospital Medical College, in succession to Prof. J. L. D'Silva (see *Nature*, **184**, 405; 1959), entered St. Mary's Hospital as a Scholar soon after the outbreak of the Second World War. After qualifying, he held a research studentship in the Wright–Fleming Institute, and having obtained the M.R.C.P. spent the remainder of the War as casualty physician at St. Mary's and as resident physician to the E.M.S. Hospital at Amersham. After the War, he worked for a year with the Friends' Ambulance Unit in China and taught at Cheeloo University. On his return in 1947 he was appointed lecturer in physiology in St. Mary's Hospital Medical School and soon afterwards also clinical assistant on the Pædiatrics Unit of the Hospital. He then settled down to study respiration and metabolism in the new-born infant, and this has remained his principal interest. He devised an accurate method for determining the infant's respiratory movements and oxygen consumption, and made a special study of the effects of lack of oxygen. The value of his investigations was soon recognized by the Sir Halley Stewart Trust and by the Medical Research Council. In 1951 he became joint organizing secretary of the symposium on anoxia of the new-born infant, arranged in London under the auspices of the International Organization of Medical Sciences. He remained at St. Mary's, being appointed reader in human physiology in 1953 and reader in physiology in 1956, and obtaining the degrees of Ph.D. and D.Sc.

His work led to more basic studies of the mechanisms of respiration in new-born animals, pursued with Dr. June Hill at St. Mary's and with Dr. G. S. Dawes and his colleagues at the Nuffield Institute for Medical Research at Oxford. Cross spent last year in Dr. Julius Comroe's laboratory at the University of California Medical Center and developed a method for inflating the infant's lungs which led to the discovery of surprising reflex mechanisms and may have opened an entirely new field. His many physiological and pædiatrical friends look forward to further important contributions from the London Hospital Medical College.

Statistics at University College, London : Prof. E. S. Pearson, C.B.E.

At the end of the current session Prof. Egon Sharpe Pearson retires from University College, London, and for the first time in seventy-six years there will no longer be a Pearson in charge of the statistics at the Department there which has become world famous. Egon Pearson was educated at Winchester and Trinity College, Cambridge, and continued his studies in statistics at University College, London, where he became a lecturer in 1921. Not long afterwards Jerzy Neyman joined the Department, and before long he and Egon Pearson began a remarkable series of papers which effectively laid the foundations of the Neyman-Pearson theory of statistical inference, undoubtedly one of the profoundest influences on modern statistical thought. Pearson has continued to work in this field and the related area of confidence-interval theory and has notably advanced knowledge of the sample range. His work on the Ordnance Board of the Ministry of Supply during the Second World War was recognized by his appointment as C.B.E. in 1946. He has also taken particular interest in the teaching of statistics; his work both at University College and as chairman of various committees of the Royal Statistical Society has laid both students and colleagues under a heavy burden of indebtedness to him for his constant endeavours to raise the standards of statistical instruction. He was president of the Royal Statistical Society during 1955–57 and received the Society's Gold Medal in 1955.

For about 25 years Pearson has been editor of *Biometrika*, and the high standing of that journal is largely due to his painstaking work and constant care. Another of his many contributions has been his work on statistical tables, embodied in the Pearson–Hartley "Tables for Statisticians, Part 1", and the *Biometrika* series of reprints. His many friends will be glad to know that he intends to devote a good deal of his time to continuing this work.

Prof. M. S. Bartlett

Prof. Maurice Stevenson Bartlett, professor of mathematical statistics in the University of Manchester, is to succeed Prof. Pearson. Prof. Bartlett read mathematics at Queens' College, Cambridge, and was awarded the Rayleigh Prize in 1934. After a short period as assistant lecturer at University College, London, and four years as statistician with Imperial Chemical Industries, Ltd., he returned to Cambridge as a lecturer in statistics in 1938. With the late John Wishart he helped to introduce modern statistical methods there and contributed some noteworthy research papers in a wide range of subjects: experimental design, factor analysis, regression theory and statistical inference. He was appointed to the chair of mathematical statistics at Manchester in 1947, and has worked there since that time. His principal contributions in more recent years have lain in two main fields, multivariate analysis and stochastic processes including time-series, both of them complicated and difficult subjects in which his work has given him a world-wide reputation.

Communication Research at Keele : Prof. Donald M. MacKay

The University College of North Staffordshire, Keele, has appointed Dr. Donald M. MacKay to the new Granada research chair of communication, founded by a gift of Granada Television Network, as from June 1, 1960. Dr. MacKay, who is at present reader in physics at King's College, London, graduated from the University of St. Andrews in 1943. After war-time work on radar with the Admiralty, he joined the staff of King's College, where he was concerned with the early development of information theory and the theory of 'brain-like' self-organizing information systems. On the experimental side, a period of research on the informational limits of high-speed analogue computing led to his present interest in the mechanism by which information is processed in the central nervous system.

The work at the University College of North Staffordshire is expected to develop along three main lines: (1) the study of perceptual mechanisms, and the development of methods for the analysis of electrical brain-activity in perception; (2) the development of artificial mechanisms capable of identifying patterns in space or in time, as an experimental 'testing ground', for theories of perception; (3) the study of disorders of function, as clues to the organization of the brain. Research on these interdisciplinary lines will require the collaboration of physiologists and experimental psychologists as well as of physicists and electronic engineers; and the setting up of an independent University department at Keele for the purpose marks a significant step in the academic development of this new subject. Dr. MacKay's gifts as a research worker and a teacher will be sorely missed at King's College; but we may surely look forward to a period of great activity and development in his new environment. In spite of his new responsibilities, we may also be sure that his interest in undergraduates and their problems will continue undiminished.

Principalship of Fourah Bay College : Dr. D. Nicol

Dr. Davidson Nicol has been appointed principal of Fourah Bay College, the University College of Sierra Leone, in succession to Mr. J. J. Grant. Dr. Nicol was educated at primary schools in Nigeria, the Government Model School, Freetown, and the Prince of Wales School, Freetown. In 1943 he entered Christ's College, Cambridge, having won an open Colonial scholarship for medicine. He was elected Foundation Scholar at Christ's College in 1946 and also in that year was the Open Universities Entrance scholar to the London Hospital. In 1947 he obtained first-class honours in the Natural Sciences Tripos and he graduated in medicine at the London Hospital in 1950. Dr. Nicol was awarded a Beit Memorial Fellowship for Medical Research in 1954, and when he became a Fellow of Christ's College, Cambridge, in 1957, he was the first African to be elected to a fellowship at either Oxford or Cambridge. During 1952–54 he was lecturer in physiology and biochemistry in University College, Ibadan,

Nigeria, and has been guest lecturer in the University of Toronto and at a number of American universities. He is at present senior pathologist and head of the Laboratory Services of Sierra Leone.

Recruitment of Teachers in Britain

In replying for the Government in an adjournment debate in the House of Commons on the supply of teachers of mathematics, which was opened by Mr. A. Skeffington and Mrs. E. White on May 9, the Parliamentary Secretary to the Ministry of Education, Mr. K. Thompson, said that a survey carried out in the schools in March 1959 showed that there are 5,100 people with honours degrees teaching mathematics in maintained schools, and 4,500 of these were in 2,600 maintained secondary schools with General Certificate of Education courses in mathematics or science, in which at that time there were 250 vacancies for honours graduates to teach mathematics. In these 2,600 schools there are also 3,250 non-graduate specialists teaching to General Certificate of Education standards. Mr. Thompson pointed out that of honours mathematics graduates from British universities, two-thirds already go into the educational system at some point and the universities are increasing their output. If the proportion recruited for teaching could be increased, this would be done. He also stated that during the period when teaching qualified a man for deferment from National Service, there was a net gain of about 500 honours graduates into the teaching profession, and that this modest gain had continued since 1957 when honours graduates had been completely free to choose between industry and the teaching profession. Mr. Thompson thought that the debate had not been completely fair to those coming from training colleges in Britain: he is confident that many of them are quite capable of teaching mathematical subjects and some of the sciences to Ordinary level General Certificate of Education standard with success, and some of them would be able to take these subjects at a higher level. Apart from his reference to attempts to attract more university graduates into the schools, Mr. Thompson stressed the need to attract more married women to come back into teaching either full-time or part-time, and he referred to the refresher and short courses in mathematics promoted by the Ministry, and to the 106,000 Ordinary level and 21,000 Advanced level passes from maintained secondary schools, compared with 71,000 and 13,000, respectively, in 1954.

British Books for Export

In a written answer in the House of Commons on May 9, the Chancellor of the Duchy of Lancaster, Dr. Charles Hill, stated that the Advisory Committee on the Selection of Low-Priced Books for Export has made good progress, and he understood that the Committee will shortly recommend its first list from the 2,000 titles put forward by publishers and others to the Ministers concerned. The Advisory Committee is also studying a first list of some twenty-five scientific and technical text-books for issue in low-priced editions for university and college libraries, instructors and students. The Government has decided to give a measure of priority to university text-books in view of the importance attached by the Commonwealth Educational Conference to the supply of books of educational, scientific and technical value. Initially, the arrangement will be applied in India, and subject to negotiations with publishers, it is hoped that low-priced editions of text-books will be made available for distribution through normal trade channels in India by December next. The size of editions will depend upon demand, among other factors, but the Government has in mind editions of up to 5,000 copies of the more specialized and advanced university text-books.

Dental Research in Britain

In answer to a question about dental research in the House of Commons on May 9, Mr. D. Walker-Smith, Minister of Health, as representing the Minister for Science, said that current annual expenditure on dental research by the Medical Research Council exceeds £35,000, and that at least one quarter of the annual expenditure of £750,000 of the university dentistry departments is spent on research. The Minister is not satisfied with the scale of dental research in Britain, and he attributes the position to lack of interest and enthusiasm on the part of dentists and graduates in science.

European Co-operation for Science

A major project in international co-operation in science education is to be launched as the result of an agreement signed between the Minister of Education and the Organization for European Economic Co-operation. The project will consist of a series of films aimed at stimulating the interest of young people in scientific subjects and made by a number of national organizations. The organizations are: the Educational Foundation for Visual Aids (United Kingdom); Institut Pedagogique National (France); Institut für Film und Bild (Germany); Statens Filmcentral (Denmark); Statens Filmsentral (Norway); Nederlandse Onderwijs Film (Holland). The contribution of the United Kingdom will be a film on 'Faraday' and the others are: "The Atomic Age" (Denmark); "Fight against Bacteria" (France); "Discovery of the Rare Gases" (Holland); "The Story of X-Rays" (Germany); and "The Story of Electrochemistry" (Norway). The scheme, initiated by the United Kingdom, received the full support of the national organizations represented on the International Council for Educational Films. It has been made possible by financial help from the Organization for European Economic Co-operation which is contributing half the cost, the remainder being provided by the national organizations already mentioned. The project will be organized by the Educational Foundation for Visual Aids. When complete, the films will be available to all schools in the member countries of the Organization for European Economic Co-operation.

The Association of Universities of the British Commonwealth

The report of the Executive Council of the Association of Universities of the British Commonwealth for the year ended July 31, 1959, includes the usual particulars of appointments in which the Association was asked to act in one way or another (pp. 28. London: Association of Universities of the British Commonwealth, 1959). These totalled 720, compared with 651 in 1957–58, and the office dealt with 4,896 inquiries, of which 4,260 related to advertised appointments. Eighty advisory committees were convened and reports sent to the universities concerned on 139 candidates. Of the 115 candidates making application through the Association whose

appointment was announced by member universities, eighty were in Australia. Membership of the Association now comprises 102 universities, 15 university colleges and 4 other institutions, and some notes on the meetings of the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom are appended to the report.

Fuel Abstracts and Current Titles

THE annual report of the Council for the Institute of Fuel for the year 1959 makes reference to a new publication that will be called *Fuel Abstracts and Current Titles* (The Institute of Fuel. Report of the Council and Statement of Accounts for the year 1959. Pp. 16. London: Institute of Fuel, 1960). The first number is expected to be issued in mid-May. With the changes that took place in the reorganization of fuel research following the cessation of the activities at Greenwich of the Fuel Research Board, the Department of Scientific and Industrial Research had ceased to publish the most successful series of abstracts known as *Fuel Abstracts*. It was recognized by many fuel interests that the entire disappearance of the undertaking should not be allowed to occur, and therefore efforts have been made by the Institute to keep the venture alive. The problem has been to find the necessary financial support, and the Council of the Institute now announces that such further support has been promised for a period of development to a self-supporting stage to an extent to justify the Institute in undertaking the responsibility of publication. One of the major problems of modern technological development is that of keeping in touch with the really important scientific advances. Accordingly, the function of such an undertaking is invaluable. This is particularly the case since one of the weaknesses of our modern scientific activity is the amount of repetitive work that is done, mainly because the records of past achievements have not been adequately reported, or that the investigators themselves have not been able to consult the volumes in which the work was originally reported. In other words, in the battle for progress our lines of communication have been weak. In the present context the moral is obvious, and it is hoped that the new venture will supply the necessary strength.

Journals and the Science of Glass Making

DURING the forty-three years of its existence, the *Journal of the Society of Glass Technology* achieved world-wide recognition as the leading publication in its field; this pre-eminence was due, in no small measure, to Emeritus Prof. W. E. S. Turner, who was editor for thirty-five years and a leading contributor to its pages. It is fitting that Prof. Turner should have been invited to write a foreword to the twin offspring of 'his' journal. Of recent years, glass-making—and for that matter the related industry of ceramics—has become firmly based on fundamental science applied through a complex technology. New work for the glass industry has become increasingly varied and the Society of Glass Technology has decided to distinguish between that which is technological and that which is more a matter of pure chemistry and physics; papers of the former type will in future appear in *Glass Technology*, papers of the latter type in *Physics and Chemistry of Glasses*. In the first issue of *Glass Technology* there are articles on glass-furnace refractories and on glass-making machinery (1, No. 1; February 1960. Pp. xl+68. Published bi-monthly. 25*s*. per issue or 135*s*. per volume). *Physics and Chemistry of Glass* contains papers on the strength of glass-fibres, the viscosity of sodium germanate glasses, the structure of boric oxide and borate glasses, and the change in the hardness of some simple glasses with increasing temperature (1, No. 1; February 1960. Pp. 54. Published bi-monthly. 25*s*. per issue or 135*s*. per volume). Each journal carries its own collection of appropriate abstracts. Both are edited by Prof. R. W. Douglas, who is to be congratulated on their excellent lay-out and presentation. A joint annual subscription can be obtained at 200*s*.

Cytology

A NEW Russian journal is to be devoted to cytology (*Cytology*, 1, No. 1. Editor in chief, A. S. Troshin. (In Russian.) Pp. 140. Moscow: Akademii Nauk SSSR, 1959). 'Cytology' is regarded for this purpose as encompassing a rather wide field, including nerve and muscle physiology and radiation biology, for example, as well as more narrowly cytological topics. It seems clear that there is at the present time in the Soviet Union a considerable expansion of effort and widening of interests, so far as studies at the cellular and sub-cellular levels are concerned. The recognition in the editorial preface of *Cytology* of the fact that contributions from the U.S.S.R. have lagged behind foreign work in some fields of cytology (especially in sub-microscopic structure, cytogenetics and cytochemistry) is unfortunately underlined to some extent by the contents of several of the papers in the first issue. The future development of cell biology in the U.S.S.R. will be watched with a great and friendly interest. It is therefore very much to be hoped that, until such time as a complete translation service is available for this journal, there will be included, in addition to the present contents list in English, an English summary of each paper in future issues.

Russian Journal of Physical Chemistry

THE Chemical Society, in co-operation with the Department of Scientific and Industrial Research, is issuing a translation of the *Russian Journal of Physical Chemistry*, beginning with the Russian July 1959 issue. The English version appears about three months after the Russian, and each part contains about twenty illustrated papers and shorter notes. The English editor is R. P. Bell. Each number is of about 112 pages, 8½ × 11 in., in covers. Most of the papers are quite short and a wide field of interest is covered. Much very good work in physical chemistry has been appearing in the U.S.S.R. (the tradition goes back over a long period of time) and chemists generally will be glad to have this translation available. The print is clear. The symbols in the mathematical equations are rather small, although they are clear. It is noticed that Russian translations of English and American works are referred to instead of the originals. The price of the first eighteen monthly issues (corresponding with the Russian issues for July 1959–December 1960) is £45 or 135 dollars, with a reduction of 25 per cent for colleges and universities. Thereafter, the annual subscription, beginning with the Russian January issue, will be £30 or 90 dollars, with the same reduction. The world distributors are Cleaver-Hume Press, Ltd., 31 Wright's Lane, London, W.8, from whom further information can be obtained.

Document Micro-reproduction

"Microtexts as Media for Publication" (Hertfordshire County Council Technical Information Service, Hatfield. 9s.) records the papers and discussion of a symposium held at Hatfield Technical College in November 1959. The organizers are to be congratulated on getting as main speakers three of the best known names in the microtext field—Mr. Eugene Power, of University Microfilms, Inc., who spoke about successes achieved with microfilm, particularly in the academic field; Dr. L. J. van der Wolk, director of the library of the Delft Technical University, on the increasing use of microfiche (that is to say, flat film, 75 × 125 mm. or 90 × 120 mm., containing 8–100 pages); and Mr. C. D. Gelatt, on the 'Microcard'. The experts in three forms of document micro-reproduction have not previously been heard together in Great Britain, and it is noticeable that there is no feeling of competition between them; each believes that there is a place for his particular form of microtext. The booklet also reproduces a delightful talk given in London early in 1959 by Fremont Rider, whose book, "The Scholar and the Future of the Research Library", originally published in 1944, suggested 'Microcards' to the library world. The idea was taken up by Mr. Gelatt, who was and is an industrialist in Wisconsin. He endowed the Microcard Foundation with 100,000 dollars, and the success of the idea is apparent when we remember the millions of 'Microcards' being made for the International Geophysical Year and the Atomic Energy Commission. (This booklet's 88 pages are reproduced on two 'Microcards' placed in a pocket on the inside of the back cover.) The pamphlet will be of great interest to librarians and others concerned with the newer ways of publishing and photocopying.

Radiochemistry of the Elements

The Subcommittee on Radiochemistry of the Committee on Nuclear Science of the United States National Academy of Sciences (National Research Council) is sponsoring a series of monographs on the radiochemistry of the elements, three volumes of which, on cadmium, arsenic and francium, have now been issued (National Academy of Sciences—National Research Council. Subcommittee on Radiochemistry. NAS-NS-3001: The Radiochemistry of Cadmium. By James R. DeVoe. Pp. vi+57. 75 cents. NAS-NS-3002: The Radiochemistry of Arsenic. By Harold C. Beard. Pp. vi+27. 50 cents. NAS-NS-3003: The Radiochemistry of Francium. By Earl K. Hyde. Pp. vi+34. 50 cents. Washington, D.C.: Office of Technical Services, Department of Commerce, 1960). It is expected that about fifty volumes will be issued within the next six months.

Preventive Aspects in the Teaching of Pathology

In the past the practice of medicine was almost wholly, if not altogether, confined to the treatment of patients. Nowadays, the doctor is often called upon to apply his knowledge for the prevention of disease. This change in medical practice is being increasingly recognized by the medical schools with the introduction of preventive medicine and social medicine into the curriculum, not as an isolated subject, but as one integrated with the other disciplines. In 1957 a Study Group was convened by the World Health Organization to consider how the preventive aspects of medicine could be introduced into the teaching of physiology. A similar task has now been undertaken for pathology by the Expert Committee on Professional and Technical Education of Medical and Auxiliary Personnel (World Health Organization. Technical Report Series No. 175: Preventive Aspects in the Teaching of Pathology—Seventh Report of the Expert Committee on Professional and Technical Education of Medical and Auxiliary Personnel. Pp. 30. (Geneva: World Health Organization; London: H.M. Stationery Office, 1959.) 1 Swiss franc; 1s. 9d.; 0.30 dollar). In its report, the Committee points out that the essential task of the teacher of pathology in promoting the concept of prevention is to trace the complete evolution of lesions, paying special attention to their causation, their progressive development, and the disturbances in function that they bring about. He is in a particularly advantageous position to show the stages in the progress of the disease at which the changes are still reversible, and so the limits beyond which efforts at prevention and cure become increasingly less effective.

Semiconductor Components

The front cover of the 1959 annual report of Texas Instruments, Inc., consists of a full colour photomicrograph showing the crystal structure of a high-purity bismuth telluride bar made during thermoelectric experiments in the Texas Instruments Central Research Laboratories (Texas Instruments, Inc. Annual Report, 1959. Pp. 20. Dallas: Texas Instruments, Inc., 1960). The report states that during 1959 the company continued its pattern of rapid growth and improvement of operations, with an increase of 110 per cent in sales and 136 per cent in net income over the previous record. The total personnel increased from 7,500 to 15,000. Three new buildings were completed on the 300-acre estate in North-east Dallas, and an addition to the semiconductor-components plant and a building for the manufacture of basic semiconductor and other materials are under construction. During September the construction of a new 120,000-sq. ft. plant was begun at Bedford, England, for Texas Instruments, Ltd., a subsidiary company, which manufactures semiconductor devices for the markets of the United Kingdom and Western Europe. The plant will be completed late this year and will augment the 35,000-sq. ft. factory now in use. The work of the Metals and Controls Division and of the Geosciences and Instrumentation Division is briefly described and illustrated in the report. In addition, the revolutionary new solid circuit semiconductor introduced in March 1959 is discussed. This product represents a new approach to electronic circuitry and component miniaturization, providing an entire circuit in a single-crystal semiconductor slab no larger than a match head. Nearly a dozen different types of circuits have already been produced and many more can be constructed using the existing techniques. The first applications are to computers, missiles, rockets and space vehicles.

Acoustic Tiles for Noise Control

It is sometimes possible to make considerable improvements by controlling noises at their sources. In the many cases where this cannot be done, sound-absorbing materials can be used to reduce noise to an acceptable level. Investigations in the Architectural Physics Section of the Division of Building Research of the Commonwealth Scientific and Industrial Research Organization, Highett, Victoria,

have made it possible to determine the characteristics of sound-absorbing materials. The information obtained has enabled the Section to assist Australian firms in the design and manufacture of acoustic tiles and other sound-absorbing materials (*Industrial Research News*, 19 ; January 1960). In offices, halls and houses extensive use is made of acoustic tiles. These are relatively costly, but have substantial advantages over most other sound absorbers in both appearance and performance. A typical tile consists essentially of a perforated facing of metal or plaster and behind this a blanket of fibrous material, such as mineral wool. In Australia, tiles of this kind, with plaster facings, have become well known and are used to a greater extent than in most countries. With the growing demand, the number of firms producing acoustic tiles has increased considerably in the past few years and the Division has received many inquiries concerning their design. Dr. W. K. Lippert and Mr. W. Davern have been concerned both with research on the basic characteristics of sound-absorbing materials and with tests on products submitted by manufacturers.

Snow Loads and Roof Designs

In Canada, the heaviest load for which the roof of a building must normally be designed is the load imposed by snow. The magnitude of the design snow-load is thus of considerable importance. It must be high enough to reduce the probability of failure to an acceptable level, but not so high as to result in unreasonable construction costs. Snow loads to be expected in different locations across Canada are given in the National Building Code. These loads are based directly on measurements of maximum ground snow depths over a number of years and are generally considered to meet the requirements of safety. Appreciating the influence of design snow-loads on the cost of construction, the National Research Council Division of Building Research decided to undertake a study of the actual accumulations of snow, ice and rain on roofs as well as on adjacent ground. It was realized that this study must be carried out for a number of years and take into account the whole of Canada. Before embarking on this project, a pilot survey was conducted during the 1956–57 winter. Its results showed that a country-wide survey of actual snow loads on roofs would yield useful information, and that the proposed method and apparatus used would, with a few changes, be suitable for the full survey. More detailed investigations have since been carried out in successive winters, each time increasing the number of locations. A more detailed report of these investigations is to be found in the February issue of *Discovery*.

Organic Acid Synthesis in Tomato Roots

In studies of metabolism in tomato roots, J. van Die has ascertained that carboxylic- and amino-acids are synthesized in the roots and translocated to aerial regions of the plant (*Koninkl. Nederl. Akad. Wetens., Proc.* C, **62**, No. 5, 504 ; 1959). In experiments in which potassium bicarbonate-^{14}C was supplied to the roots of plants in sand culture, he found that a few minutes after supplying the tracer to the roots, labelled organic compounds could be detected in the bleeding sap. After about 15 min. the secretion of active compounds reached its maximal rate, which was maintained for several hours. Analyses of the bleeding sap showed that most of the activity was present in the organic acid fraction, with malic acid as main constituent, followed by citric acid and a number of still unidentified acids. About 15 per cent of the activity was localized in amino-acids, and a small amount in α-ketoglutaric acid. In the roots the largest part of the activity was found in the organic acids and α-ketoglutaric acid, while only small amounts of active amino-acids were present. About 10 per cent of the activity of the roots was localized in proteins.

Geological Society of London

At the annual general meeting of the Society, held at Burlington House on April 27, the officers and Council for the ensuing year were elected, as follows : *President*, Prof. S. E. Hollingworth ; *Vice-Presidents*, Mr. A. J. Butler, Mr. T. C. Nicholas, Sir William Pugh, Dr. C. J. Stubblefield ; *Secretaries*, Mr. J. M. Edmonds, Dr. P. A. Sabine ; *Foreign Secretary*, Prof. O. T. Jones ; and *Treasurer*, Mr. P. Evans. *Council Members*, Prof. J. G. C. Anderson, Dr. H. W. Ball, Prof. O. M. B. Bulman, Mr. A. J. Butler, Prof. K. C. Dunham, Mr. J. M. Edmonds, Mr. P. Evans, Prof. T. N. George, Prof. W. D. Gill, Dr. D. R. Grantham, Prof. S. E. Hollingworth, Dr. R. G. S. Hudson, Prof. O. T. Jones, Prof. B. C. King, Dr. W. S. McKerrow, Mr. T. C. Nicholas, Sir William Pugh, Dr. Dorothy Rayner, Dr. P. A. Sabine, Prof. R. M. Shackleton, Dr. C. J. Stubblefield, Prof. J. Sutton, and Prof. P. C. Sylvester-Bradley.

Seventh Commonwealth Entomological Conference

The seventh Commonwealth Entomological Conference will be held in London during July 7–16, delegates to it being nominated by the Governments of the various countries of the Commonwealth, including many of the Colonial Territories. The proceedings of the Conference will include a number of open meetings, to be held in the Memorial Hall of the Royal Geographical Society (Exhibition Road entrance), South Kensington, London, S.W.7, on July 7, 8, 11, 12 and 14, and these will be open to all entomologists and others who may be interested, whose participation in the discussions will be welcomed. At each session a subject of wide interest to economic entomologists will be introduced by one or more invited speakers. The subjects are as follows : recent developments in insecticides for crop protection ; problems of applying insecticides ; hazards and precautions associated with the use of pesticides ; research on stored-products pests and their control ; biological control of insects and weeds ; insect attack in relation to the physical characters and physiological state of the plant ; investigations on timber-boring beetles ; termite control in afforestation projects and constructional timbers ; pathogenic organisms for the control of insect pests ; current trends in the study and control of tsetse flies and of locusts ; studies of dispersal of insects in relation to their control ; developments in the study of plant viruses and their vectors ; the link between research and its application in the field of plant protection. Programmes giving full details will be available about four weeks before the Conference from the Director, Commonwealth Institute of Entomology, 56 Queen's Gate, London, S.W.7.

University News : Cambridge

Matriculation requirements are to be modified. Each candidate will be required to hold the General

Certificate of Education (Ordinary Level) in the use of English, two languages other than English, mathematics or a science subject, and one other subject; in addition, two passes at Advanced Level in approved subjects will be necessary. Thus, the classical languages, and in particular Latin, are no longer compulsory subjects.

The Night Sky in June

Full moon occurs on June 9d. 13h. 02m. U.T., and new moon on June 24d. 03h. 27m. The following conjunctions with the Moon take place: June 10d. 07h., Jupiter 5° S.; June 11d. 10h., Saturn 4° S.; June 18d. 19h., Mars. 2° N.; June 22d. 04h., Aldebaran 0·5° S. In addition to these conjunctions with the Moon, Mercury is in conjunction with Pollux on June 20d. 05h., Mercury being 6° S. Mercury is an evening star, visible low in the west after sunset; it sets between one and two hours after the Sun. Venus is too close to the Sun for observation. Mars rises at 1h. 50m., 1h. 15m. and 0h. 35m. at the beginning, middle and end of the month, respectively; it is in Pisces on June 1 and moves into Aries on June 20. Its stellar magnitude is + 1·0 and its distance from the Earth on June 15 is 151 million miles. Jupiter rises at 21h. 30m., 20h. 30m. and 19h. 30m. on June 1, 15 and 30, respectively, and sets at 3h. 10m. on June 30; it is thus above the horizon throughout the hours of darkness. It is in Sagittarius, its stellar magnitude is − 2·2, its distance from the Earth in the middle of the month is 400 million miles, and it is in opposition on June 20. Saturn is also in Sagittarius, rising at 22h. 35m., 21h. 35m. and 20h. 35m. on June 1, 15 and 30, respectively. Its stellar magnitude is + 0·4 and its distance from the Earth on June 15 is 845 million miles. There are no occultations of stars brighter than magnitude 6 visible at Greenwich. The summer solstice occurs on June 21d. 10h.

Announcements

Prof. D. G. Christopherson, professor of applied science in the Imperial College of Science and Technology, London, has been appointed warden of the Durham Colleges in succession to Sir James Duff, who is retiring.

Dr. Milo P. Hnilicka has been appointed to the new post of scientific assistant to the vice-president and director of research for the National Research Corporation of the United States. Dr. Hnilicka will act as scientific advisor to the director of research and as a consultant on a number of projects now under way. His assignments will include technical liaison on new projects between the National Research Corporation and other laboratories in the United States.

A dinner in honour of Mr. F. Howarth, on the occasion of his retirement from the Botany Department, Imperial College of Science and Technology, will be held on July 15 at the College. Old students who wish to attend this dinner, and who have not already been invited, should write as soon as possible to Dr. A. J. Rutter or Dr. R. K. S. Wood, Imperial College, London, S.W.7.

The University of Maryland is to receive a grant of 216,000 dollars from the U.S. National Aeronautics and Space Administration to accelerate its programme of basic research dealing with the growth and metabolism of unicellular algae. Since 1949 personnel in the University's Department of Botany under the direction of Dr. Robert W. Krauss, professor of plant physiology, have been engaged in fundamental studies on the physiology of algae.

The sixteenth International Congress of Zoology will be held in Washington, D.C., during August 21–27, 1963, under the presidency of Dr. Alfred S. Romer, Alexander Agassiz professor of zoology and director of the Museum of Comparative Zoology, Harvard University.

An international conference on "Science in the Advancement of New States" is to be held in Israel during August 15–30 under the auspices of the Weizmann Institute of Science. Further information can be obtained from the Scientific Attaché, Embassy of Israel, 2 Palace Green, London, W.8.

A conference on "The Chemical Organization of Cells: Normal and Abnormal" will be held at the University of Wisconsin, Madison, during August 25–27. Further information can be obtained from Dr. J. F. A. McManus, Department of Pathology, University of Alabama Medical Center, Birmingham, Alabama.

The seventh international conference of the Society for Biological Rhythm will be held at Siena, Italy, during September 5–7 in conjunction with the International Basimetric Society. Further information can be obtained from Dr. A. Sollberger, Department of Anatomy, Caroline Institute, Stockholm 60.

The tenth Pacific Science Congress of the Pacific Science Association will be held in the University of Hawaii, Honolulu, during August 21–September 6, 1961. It will be sponsored by the U.S. National Academy of Sciences and Bernice P. Bishop Museum, Honolulu, with the co-operation of the University of Hawaii. Scientific sessions will be held during August 21–September 2, with a post-sessional field-trip until September 6.

The fifteenth Calorimetry Conference will be held at Gatlinburg, Tennessee, during September 7–10. Among the topics to be considered are: precision reaction and bomb calorimetry, solution calorimetry, microcalorimetry, heat-capacity measurements at low and high temperatures (0·1–1,400° K.); temperature scales and standard calorimetric samples, etc. Those wishing to attend or to present a paper should write to Dr. J. P. McCullough, Bureau of Mines, Box 1321, Bartlesville, Oklahoma.

The Royal Meteorological Society is organizing a two-day meeting to be held at Queen's College, Dundee, during June 29–July 1. The meeting will take the form of two symposia, namely: "Convection" (June 30); and "Agricultural Meteorology" (July 1). Contributors to the symposium on convection include F. H. Ludlam (Imperial College of Science and Technology), C. Dixon (Queen's College, Dundee), F. W. G. Warren (University of Sheffield) and R. P. Peace (Queen's College, Dundee). Contributors to the symposium on agricultural meteorology include H. L. Penman and J. L. Montieth (Rothamsted Experimental Station) and G. J. Day and R. W. Gloyne (Meteorological Office).

Erratum. In the article entitled "A Synoptic Study of Infra-Red Radiation over the United States" by Dr. J. L. Gergen and Dr. W. F. Huch (*Nature*, May 7, p. 426), the units are printed incorrectly as "MW."; they should be "mW.".

THE SERENGETI NATIONAL PARK

By Dr. A. S. THOMAS

THE magnificent film "Serengeti shall not die" is not only pictorially beautiful but also scientifically fascinating. The film shows that the game animals amount to only about 367,000 instead of the million previously estimated; it shows that the migration routes lie outside the southern boundaries of the National Park, and that none of the herds goes near the area to the north, proposed as an extension of the Park; and it shows how the grasses were being investigated to discover the preferences of the antelopes.

The film itself goes far to answer the grass question; much of that on which the antelopes were grazing appeared to be *Themeda triandra*, but, whatever the species, the grass was always short, less than 2 ft. high and often reduced by fire or grazing to a few inches. Not only do antelopes like short grass for grazing but also they need it for observation of their predators, the lions and hyenas.

Prof. W. H. Pearsall recommended in his report[1] "That arrangements be made for the early exclusion of pastoral occupation from the National Parks" and that recommendation was adopted by the Board of Trustees of the Park in its 1957–58 report. Have trials been made to discover what will happen to the Serengeti grassland if it is protected from fire and from grazing? Much of it would probably grow to 6 ft. or more, much too tall to suit the smaller antelopes.

Some indication of what will happen may be seen in other places; I will mention two of them. The first place is the Gulu elephant sanctuary in Uganda, where the grass of the uninhabited area is up to 9 ft. high and is almost deserted by antelopes, which swarm on the shorter grazing lands at the edge of the sanctuary. The other place is the National Park in the Belgian Congo, east of Lake Edward, from which the sparse pastoral population was moved, with the result that the grassland grew so tall and coarse that the population of antelopes was much reduced. "Man certainly is an important member of the biome in Africa; human settlement is not, as might be imagined, solely antipathic to the increase of wild animals; the pastoral tribes, by controlled burning, produce flushes of grass which benefit not only their stock, but also the wild animals as well"[2].

As I have visited the Serengeti only once, I do not know it well, but I can think of no difference in the soil to account for the migration of antelopes outside the southern boundary of the National Park; it must be that the grass there is shorter, as they prefer it. Similarly, the area north of the Park, and suggested for inclusion in it, may well be avoided by game animals because it has little human population, little grazing by cattle, and the grass is therefore too long for the antelopes.

Prof. Pearsall noted the over-grazing and erosion from the flocks and herds of the Masai: "Even where the Masai cattle alone are using the grasslands there is evidence of grassland deterioration and it seems clear that it would not be possible for both cattle and game to occupy the same areas permanently". But, if there were more sources of water, more frequent movement of the stock, might there not be less erosion, less competition for grazing near the water holes?

The area of the Serengeti National Park is about 5,000 square miles, or 3,200,000 acres. The Masai cattle number about 120,000, sheep and goats about 220,000, donkeys about 6,000 (ref. 1). It is usually accepted that about eight grazing sheep or goats may be reckoned as equal to one ox; therefore, the total livestock of the Masai may be considered as about 150,000 units; there are about 3,000,000 acres of grazing, so there are about twenty acres of grazing for each head of cattle.

The soil analyses in Prof. Pearsall's report show good supplies of bases; there seem to be no marked deficiencies as in the acid grasslands to the west of Lake Victoria. The average rainfall of the National Park is about 30 in. a year; there is a dry zone near the eastern volcanic hills, but the hills themselves have more precipitation. As the Serengeti is near the equator, the rainfall is fairly well distributed, with two dry seasons and two wet seasons each year.

Under such conditions, is it not reasonable to expect that, with correct management, the Serengeti plains could support both the Masai stock and the game animals (a large proportion of which are small antelopes) without undue damage to the grass and the soil? It has long been evident that the management of the large open plains, and not the management of fenced pastures on European farms, is the main problem of grassland research in East Africa; that point was emphasized at the first East African Grassland Conference, held nearly twenty years ago. In spite of deficient knowledge about the management of the plains, of possible difficulties in arranging supplies of good water by dams and boreholes, yet it should be possible to preserve the grass and the game without displacing the Masai who are living in the area.

Scientists should be grateful to the Fauna Preservation Society, which arranged that Prof. Pearsall should visit Serengeti and made a comprehensive report on problems which had been given little definite scientific study; they should be grateful to Dr. Grzimek for all he did at his own expense; but above all they should be grateful to gallant young Michael Grzimek, who gave not only his money, but also his life, to this work.

With the rising tide of African nationalism, is there not a danger that we may be thought to devote too much attention to the animals of Africa and not enough to the people? David Howarth[3] has directed attention to the disparity of publicity about "Operation Noah", in which four or five thousand animals were taken to safety, and the plight of fifty thousand Batonga people who had to leave their homes before the flood of the Kariba Dam. Must we not make it clear that we are more concerned with the welfare of African peoples than of African animals?

May not the future of the animals be more secure if the Masai continue to live in the National Park of a self-governing Tanganyika? Is there no risk that an African Government will not look favourably on

a large tract from which the Africans have been displaced and which to them seems reserved for animals and for American and European tourists ?'

If the National Park is preserved from fire and from grazing, the grass may soon be too long for the antelopes, which will go to the grazed land outside the reserve and fall a ready prey to poachers. Despite the lack of present knowledge, there must be an attempt to secure a balance of grazing which will suit both domestic stock and wild animals. The Masai are a proud and a conservative people; but they love their cattle and, if it were shown that measures were designed to maintain their herds in their present numbers, in their present homelands, I think they would co-operate.

[1] Pearsall, W. H., *Oryx*, **4**, 73 (1957).
[2] Thomas, A. S., *J. Ecol.*, **31**, 149 (1943).
[3] Howarth, D., *Sunday Times* (Feb. 28, 1960).

THE WATHEROO MAGNETIC OBSERVATORY, MELBOURNE

WATHEROO Magnetic Observatory was established in 1919 by the Carnegie Institution of Washington, at a site about 110 miles north of Perth, Western Australia, and about 50 miles from the coast. Since that date the Observatory has carried out a programme of observations in terrestrial magnetism and electricity and ionospheric research. In 1947, the Observatory was transferred by gift to the Australian Commonwealth Government, and the Commonwealth Bureau of Mineral Resources, Geology and Geophysics has operated and maintained the Observatory since then.

In recent years there has been great difficulty in maintaining Watheroo Observatory as a residential establishment: so much so that consideration had to be given to moving the Observatory to suitable sites near Perth, where it would be possible to continue observations, and at the same time avoid the expense and staffing difficulties associated with the maintenance of a residential establishment in a remote locality. It was also believed that work of the Observatory would benefit from bringing the staff in closer contact with scientific workers at the University and other establishments in Perth.

In 1955, a site was selected in the Gnangara Pine Plantation, north of Perth, for magnetic observations, and another in the vicinity of Mundaring Weir, 20 miles east of Perth, in the Darling Ranges, for ionospheric and seismological observations. A site for an office and laboratory was selected in Mundaring township. When selecting observatory sites, the Bureau sought and was guided by the advice of many local and overseas scientific authorities.

The magnetic station was completed at Gnangara late in 1956, and observations and recordings began at that station in parallel with those at the Watheroo Observatory in July 1957. Both stations were operating throughout the International Geophysical Year.

The buildings at Mundaring necessary for the transfer of ionospheric observations from Watheroo have now been completed. A new ionospheric recorder has been purchased and will be installed soon. Magnetic observations and recordings ceased at Watheroo on January 31, 1959, and on March 18, 1959, the other observatory activities were transferred to Mundaring. Seismological recording began at Mundaring in August 1959, using a three-component Benioff seismograph, with both long- and short-period galvanometers.

The new organization is known as Mundaring Geophysical Observatory, with headquarters in Mundaring township. The magnetic and ionospheric data are distributed on the same basis as for Watheroo, and seismological bulletins are issued on the same basis as for other stations operated by the Bureau.

For the particular scientific observations undertaken, the transfer from Watheroo to Mundaring will have no significant influence on the results. The move of about 100 miles is not important on the global scale. It is believed that, although Perth Observatory has operated seismographs for many years, the new Observatory will fill a real need for a high-sensitivity seismograph in this area.

Further information concerning the new establishment should be addressed to the Observer-in-Charge, Mundaring Geophysical Observatory, Mundaring, Western Australia.

THE LE PLAY SOCIETY

FOUNDED in 1930 to encourage international studies along the lines advocated in the middle of last century by the French sociologist Frederic Le Play, the Le Play Society, under the direction of Miss Margaret Tatton, has for thirty years organized an annual 3-day conference and study visits to the less-familiar regions of Europe and North Africa. The formula for the overseas work was for a group with varied backgrounds to spend a few days getting the general 'flavour' of a country and then to settle down in a village to make an intensive study of the community and its environment. In the evenings geologist, botanist, agriculturist, geographer, sociologist, doctor, teacher would meet to pool their findings and, under expert visiting and local guidance, compare notes to build up a remarkably complete picture. About a dozen such studies reached a wider audience through publication as monographs.

On April 9–12, 1960, the Society met for the last time at Wadham College, Oxford, and Sir John Russell delivered his twenty-third annual address as president. Rather than face a slow decline, the Society decided to terminate its work in a blaze of glory—the final conference dealt with "Present Problems in World Affairs", with contributions from many angles by Prof. L. F. Rushbrook-Williams (India and Pakistan), Prof. A. L. Goodhart (International Law), Sir Reader Bullard (Middle East), Prof. L. Dudley Stamp (Food and Population), Dr. F. M. Brewer—now mayor of Oxford (Science and the Ordinary Man), Mr. William E. Abraham of All Souls (African Independence), Prof. E. M. Hugh-Jones (America:

The Influence of Affluence), Mr. E. Paget (West Indies), and Mr. N. H. Leyland (Economic Problems). Old friends who assisted in this final conference included Prof. H. J. Fleure, who presented to the president a handsomely bound volume including typescripts of his series of annual addresses, Sir Richard Livingstone, who took the chair at the presidential address, Prof. Kenneth Mason and more than a hundred members, who paid tribute in the form of a presentation to mark the devoted work of Miss Tatton.

The main reason for the decision to wind up the Society is a tragic commentary on the post-war world. While international tourism is being encouraged, study groups which moved so freely and were accorded unstinted help everywhere in the inter-war years are now faced with official frustration and danger of arrest as spies if they attempt to see anything not on the accepted tourist routes. In addition, increasing costs have placed such journeys beyond the resources of younger people who, if they can get grants, are required to attend meetings in their own specialisms. Few seem to have leisure for the quiet exchange of views with workers in other fields. Le Play methods in social and regional survey have, however, become basic requirements in physical and social planning all over the world.

L. Dudley Stamp

THE LACK OF THINKING IN EXAMINATIONS

In marking examination scripts, Dr. Margaret Sutherland, lecturer in education at the Queen's University, Belfast, has noticed that many students do not deal with the topic set (*The Universities Review*, **32**, No. 7; February 1960). This occurs mainly in subjects which require a basic knowledge (of facts, or of a book, theory, or other works) and some more or less intelligent discussion of some aspect of this basic knowledge. The examiner has attempted to set a question which will differ from those set in previous papers and yet allow the students to display knowledge, select relevant data and comment reasonably thereon. To this, many students pour forth a statement of basic knowledge which is mostly without relevance to the question set.

Some examiners would classify this behaviour as 'examination technique' or conscious bluffing on the part of the students who, knowing that they are unlikely to pass, have memorized answers on strictly limited topics and are going to use them no matter what the question. But not all erring students can be credited with this conscious cunning, for some irrelevant answers display conscientious and thorough preparation.

Occasionally the explanation lies in the examiner's technique; the question may have been badly worded, the interpretation which seemed obvious to the examiner was not obvious to other readers; thus seemingly irrelevant answers may prove relevant, if the question is re-interpreted.

In other cases the weakness seems to be in the student's reading ability. The student must be technically able to read the question; but the sense of the sentence is not grasped. One word only, or part of the sentence only, dominates the rest and evokes the associations to this one element. This is an example of the so-called global thinking supposedly characteristic of early childhood, where a general concept is present or brought to mind, but finer discriminations cannot be made, and analysis, perception of detail and component parts do not occur. This leads to regression to an earlier stage of behaviour, possibly caused, like other regressions, by a stressful situation. Yet surely the concepts in question have been analysed during preparation for the examination? Surely, too, the student has been trained to attend to the different parts of meaning conveyed by whole sentences?

Does the error occur in grasping the meaning of the question or in attempting to respond to it? If it is the latter, the behaviour may be explained as regression to another primitive type of mental activity, to rote-memory in which the information sought can be reproduced only imbedded in the impressions originally accompanying it. It is difficult to believe that, having reproduced all the data, the student still cannot select from this reproduction all that is relevant.

Yet this the student seems unable to do. It is precisely selection and discussion that are avoided. It seems increasingly probable that this avoidance may be due not to ignorance of what is wanted, not to bluff or sophisticated examination technique, not to failure in reading ability, but to emotional factors of anxiety and fear. The student approaches the examination with the feeling of not knowing enough, or of not knowing the material sufficiently well to remember it all. Acute anxiety is aroused by what seems a request to be judged on only a part of what has been learned.

Yet if the relevant material were selected and discussed, the student's answer should develop fully satisfactory dimensions. The student is invited to display a lesser amount of factual knowledge, provided evidence of thought is added.

It is possible that this avoidance by the student of thinking out a new aspect is not irrational, but the result of learning from experience. Even good examination candidates considering a new aspect of a familiar subject discover that their knowledge is inadequate; items of related knowledge do not always present themselves. The candidate has either been content to accept words without close inquiry into meaning, or has learned the accepted formulæ without considering all their implications.

Even where there is no discovery of ignorance, thought does not always operate smoothly; although we have relevant points to make, they may not all occur to us, or arrange themselves in the appropriate pattern immediately. It could be argued that students should have thought so much about the subject beforehand that their thinking has become flexible and well integrated. It remains possible that the examiner calls for discussion of an unforeseen aspect. Thus the student's resistance, conscious or not, to following a new line of thought in examination circumstances (or elsewhere) might be well founded on past experience of unsuccessful effort. It is so

much easier to let thinking follow the usual path indicated by a signal word, or let memory take over from it.

This avoidance is to be deplored. It can be overcome at least partly by good teaching. Students who have had sufficient practice both in thinking about new aspects of their subject and in criticizing irrelevant responses may come to recognize more clearly what is relevant and to feel some confidence in their own ability to think independently. More independent study could also help, since thinking flexibly in a subject and perceiving most of its implications are made more easy by increasing knowledge and work in it.

RESISTANCE OF GONOCOCCUS STRAINS TO PENICILLIN

GONOCOCCUS strains isolated in 1944 were found to be highly sensitive to penicillin. From 1946 onwards, the existence of less sensitive strains were observed. Up to the end of 1955, doses of penicillin, twice to four times as great as those which were effective against the strains isolated in 1944, were enough to stop the development of the less sensitive strains isolated at the Statens Seruminstitut, Copenhagen. Then, from a case of gonorrhoea without complications, four strains were isolated which were found to be only one-twentieth as sensitive as the 1944 strains. This discovery and the fact that the incidence of gonorrhoea remained about the same in spite of penicillin therapy indicated the need for further research. This was carried out during 1957 and 1958 by Alice Reyn and M. W. Bentzon, who made a comparison of several hundred recently isolated gonococcus strains with a hundred strains isolated in 1944 (*World Health Organization Chronicle*, 14; No. 3. March 1960). This showed that, for inhibition, about 25 per cent of the strains sent to the laboratory for diagnosis in 1957 required doses of penicillin twenty times greater than had been needed for most strains originally.

Twenty strains showing reduced sensitivity to penicillin were subcultured for 30–90 days on a medium with no penicillin, without any increase in sensitivity being produced.

Both in 1957 and 1958, some 200 strains were tested for penicillin sensitivity by the tablet method, that is to say, by placing penicillin tablets in the culture medium and measuring the zone of inhibition around them. The zone diameters varied between 20 and 50 mm. In both years, about 39 per cent of the strains showed reduced sensitivity, that is to say, zone diameters of 34 mm. or less. In 1958, however, the number of strains with zone diameters of 44 mm. or more was significantly lower than in 1957, which seems to indicate that the selection (and induction) of the strains with a comparatively reduced penicillin sensitivity continues.

None of the 1957 strains was completely resistant to streptomycin, but two of the 1958 strains (from the same patient) were.

In both the 1957 and 1958 strains a significant positive correlation was observed between sensitivity to penicillin and sensitivity to streptomycin.

From June 1957 onwards, atypical gonococcus strains—most of them sensitive to penicillin—appeared in the cultures. The growth of these strains on the routine media is poor; they require special conditions for culture and are able to ferment glucose only weakly or not at all. Serological examination showed them to be distinguished from normal strains by the frequent presence of anti-complementary antigens. The proportion of atypical strains rose to 40 per cent in January 1958 when the culture and fermentation media were changed. The change of culture medium had yet another effect: the inhibition zones of the atypical strains—and of these alone—were greater on ox-heart broth than on ox-meat broth. This phenomenon has not yet been explained. It is possible that the emergence of atypical strains is related to the mode of action of the penicillin.

GLOBULAR CLUSTERS

ASTRONOMY has always suffered because of the uneven distribution of its personnel and equipment between the northern and southern hemispheres. Especially welcome, therefore, are the growing number of contributions from the Radcliffe Observatory at Pretoria. A series of three contributions by Dr. T. D. Kinman (*Mon. Not. Roy. Astro. Soc.*, 119, 157, 538, 559; 1959) represents an important addition to our knowledge of globular clusters. A study of their motions in the Galaxy is of interest because these clusters are prototypes of Baade's Population II and are believed to contain the oldest stars in the Galaxy. Kinman has obtained the radial velocities of thirty southern globular clusters, for sixteen of which no previous determinations of velocities existed; velocities are now available for seventy clusters in all, more than two-thirds of the known clusters in our Galaxy. The effect of the metal/hydrogen ratio on the strengths of the spectral lines of metallic elements in the clusters was studied by Kinman. He found that this ratio varies from 0·1 to less than 0·01 for different clusters. He also found that clusters of the earliest spectral type, the stars of which have a very low abundance of metal, form an extended spherical distribution with little concentration in the galactic plane, while those of latest type, the stars of which have the highest abundance of metal, show a strong concentration in the galactic plane. Clusters of intermediate type show an intermediate distribution.

The motion of the Sun relative to the globular clusters was determined; the apex of the solar motion does not deviate from the direction of the Sun's galactic rotation. The new analysis confirms the older conclusion that the orbits of the individual clusters in the Galaxy are highly eccentric. The mean angular momentum per unit mass of the cluster system is the same as the mean for the rest of the Galaxy. This is in accord with the hypothesis that the clusters were formed in a spherical gas cloud which was in the process of contracting to form the galactic disk.

SOME BOTTOM CORES FROM THE SWEDISH DEEP-SEA EXPEDITION, 1947–48

THE final publication of the analyses and conclusions to be drawn from the world-wide collection of cores made by the Swedish Deep-Sea Expedition during 1947–48 is still to come. However, with the enormous amount of material collected and the wide scope of the examinations, it is inevitable that the results of particular studies made by many different workers should be published separately and as soon as completed. Thus during the past two years, five fascicules, comprising ten separate papers on sedimentation problems, have been published in the series of the Expedition reports*. Some of these papers represent exhaustive studies of particular cores, whereas others merely present briefly the results of the application of one particular technique to some core material. The cores from the different oceans of the world crossed by the *Albatross* during the Expedition are dealt with in separate volumes in the reports, all papers relevant to these cores being published in one volume, consisting of several fascicules published as the results become available.

Fasc. 4 of the volume on West Pacific cores contains four papers describing a core of 4 m. taken from a depth of 7,710 m. in the Mindanao Trough. This consists of a thin layer of sand overlying a thick bed of fine-grained terrestrial mud which in turn overlies a bed deposited by series of turbidity currents, containing graded sand layers. The principal work is described by Fredriksson, who has undertaken mechanical, chemical and petrological analyses of both the fine and coarse fractions of the core. These show that the sedimentary material has been derived mainly from the andesitic to basaltic rocks of the nearby Snellius Ridge. The breaking up process is attributed to tectonic movement and volcanic explosion, the fine material being transported by sea currents and the coarser silts and sands by mud slides followed by turbidity currents.

This conclusion is confirmed by the discovery of shallow water benthonic Foraminifera in the coarse layers in the core (Reyment) and of fragments of calcareous algae known to exist in reef-building corals characteristic of shallow water (Horn af Rantzien).

Two papers by Locher describe five cores taken in the West Equatorial Atlantic basin between the Amazon Estuary and the Mid-Atlantic Ridge. All these cores show sand and silt layers with associated beds of blue mud. Mineralogical and petrographical analyses of the heavy minerals of the cores are described and show that there are significant differences between their mineral assemblages and those of samples taken from the Amazon Estuary. The sand layers, which are rich in Foraminifera, have all the properties of turbidity current deposits and are assumed to be derived from the South American continent.

The work of Norin on a core of 18 m. from the central Tyrrhenian Sea is the most complete description of any of the cores discussed here. The core consists chiefly of a calcareous pelagic clay sparsely intermixed with aerial dust and silt. The clay minerals are shown to have been largely derived from the land mass to the east, although it is suggested that the montmorillonite is authigenic. Intercalated in the column of normal pelagic sediment are many layers of coarser and darker materials. Each of these has been studied in detail and is described with regard to its mechanical and mineralogical composition. The layers can be ascribed to three different modes of deposition, each with its own characteristic composition and formation. Eruptions of nearby volcanoes contribute volcanic glass and pumice, although it has been difficult to correlate the layers with known periods of volcanic activity. Some layers with sharp boundaries both below and above are characteristic of exceptionally severe dust storms. Very small quantities of such eolian deposits are found throughout the core. Thirdly, there are the turbidity current deposits which apparently originate on a ridge nearby. The material of these deposits is highly mixed, containing volcanic ash, Foraminifera and quartz. It is thought that the quartz is first deposited on the ridge by eolian transport and later moved by the turbidity currents. A thorough study of the surrounding land geology and of the petrography of the volcanoes in the region enables a very precise study of the origin of the sediments to be made. It is unfortunate, however, that more is not known of the topography of the sea-floor surrounding the core and that more cores are not available to correlate simultaneous deposits.

In the volume on "Special Investigations", the mineral composition of the clay fraction of two cores from the Atlantic and Pacific is compared (Dekeyser and Lippman). From the rather limited data it is concluded that there are marked differences between cores but surprising constancy throughout each core. Brotzen and Dinesen have attempted to correlate the stratigraphic sections of two Pacific cores using a statistical treatment of the foraminiferal assemblages. These appear to be controlled by climatic conditions, and warm and cold periods can be distinguished.

* Göteborgs Kungl. Vetenskaps-och Vitterhets-Samhälle. Reports of the Swedish Deep-Sea Expedition, 1947–1948.

Vol. 6. Sediment cores from the West Pacific. No. 4. A sediment core from the Mindanao Trough. By K. Fredriksson, p. 97–134. No. 5. Mineralogical composition of some <2 micron fractions in a sediment core from the Mindanao Trough. By J. Ch. L. Favejee, p. 135–138. No. 6. A Note on the Foraminifera in a sediment core from the Mindanao Trough. By R. A. Reyment, p. 139–156. No. 7. Fragments of calcareous algæ in a sediment core from the Mindanao Trough. By H. Horn af Rantzien, p. 157–160. 25 Sw. kr.

Vol. 7. Sediment cores from the North Atlantic Ocean. No. 4. Sedimentpetrografische Untersuchung der Lotkerne 255 und 257. By F. W. Locher, p. 185–208. No. 5. Ein Beitrag zum Problem der Tiefseesande im westlichen Teil des äquatorialen Atlantiks. By F. W. Locher, p. 209–225. 10 Sw. kr.

Vol. 8. Sediment cores from the Mediterranean Sea and the Red Sea. No. 1. The sediments of the Central Tyrrhenian Sea. By E. Norin, p. 1–136. 35 Sw. kr.

Vol. 10. Special Investigations. No. 2. Examinations of core 72 and 723. By W. Dekeyser, p. 33–38. No. 3. X-ray determination of phillipsite in a sediment core from the Central Equatorial Pacific. By F. Lippman, p. 39–42. 5 Sw. kr. No. 4. On the stratigraphy of some bottom sections from the Central Pacific. By F. Brotzen and A. Dinesen, p. 43–55. 5 Sw. kr.

(Göteborg: Elanders Boktryckeri Aktiebolag. 1958 and 1959.)

The correlations, however, are not striking, and there is no evidence that the cores do in fact represent continuous and undisturbed sedimentation.

Perhaps the most interesting general conclusion to be drawn from this series of papers on deep sea sediments is that it is extremely rare to find a core that does represent continuous and undisturbed sedimentation. In every core described, there is evidence of a great deal of horizontal displacement of sediments after their initial deposition, by slumps, mud slides and turbidity currents. As these are processes controlled by gravity, and taking place on the bottom, the local topography is of the utmost importance. Different physiographical regions, as defined by Heezen, will have different types of sediment deposited. Any attempt at correlation between cores must take this into account.

The work that has been carried out on analysis of the cores obtained by the *Albatross* represents, perhaps, one of the most exhaustive studies ever made on deep-sea sediments. Certainly the collection of papers provides a solid mass of accurate data to which other sediment studies can be referred and which will inevitably lead to a better understanding of the processes involved in deep-sea sedimentation.

A. S. Laughton

A RELATION BETWEEN SOLAR RADIO EMISSION AND POLAR CAP ABSORPTION OF COSMIC NOISE*

By Dr. M. R. KUNDU and Prof. F. T. HADDOCK
The Observatory, University of Michigan, Ann Arbor

IONOSPHERIC absorption of cosmic noise in polar regions (called polar cap absorption) is believed to be caused by ionization of the upper atmosphere by fast protons (in the energy-range of 10–50 MeV.) emitted from the Sun after a big flare[1,2]. Direct balloon observations of protons have confirmed this hypothesis[3,4]. It is further known that, following the associated solar phenomena, the absorption event begins after a highly variable delay of 1–50 hr. The association of some proton events with metre-wave outbursts of continuum radiation has led to the belief that cosmic-ray particles, or fast protons, are accelerated by the same mechanism as the fast electrons responsible for continuum radiation, that is, synchrotron radiation from high-energy electrons accelerated in magnetic fields in the solar atmosphere. The use of polar cap absorption as a detector of low-energy cosmic rays suggests the importance of identifying the nature of solar radio emission which might be associated with these absorption events. In this article, we intend to make a statistical study of the nature of centimetre-wave as well as metre-wave radio outbursts associated with polar cap absorption events and, if possible, to draw general conclusions regarding the prediction of the proton events.

During February 1956–July 1959, 31 events of polar cap absorption have been reported[1,2]. For the radio burst data we have used the single frequency observations of the University of Nagoya on 9,400, 3,750, 2,000 and 1,000 Mc./s., of Ottawa on 2,800 Mc./s., and the dynamic spectrum records of the University of Michigan and the Harvard station at Fort Davis in 100–600 Mc./s. band and of Sydney in 40–240 Mc./s.

Metre-wave outbursts of continuum radiation characterized by its broad-band spectrum, long duration and strong polarization is called type IV radio emission, and it is believed that broad-band centimetre-wave outbursts are also of the same nature. A centimetre-wave outburst is defined as a burst of emission having a peak intensity greater than 100 units (1 unit = 10^{-22} W.m.$^{-2}$(c./s.)$^{-1}$), and we shall define the centimetre-wave outbursts having peak intensities greater than 500 units over the entire wave-length range of 3–30 cm. as intense broad-band centimetre-wave outbursts and those having peak intensities greater than 100 but less than 500 units over the same wave-length range as moderate broad-band centimetre-wave outbursts.

Of the 31 polar cap absorption events so far reported, 28 events occurred during periods of centimetre-wave observations, and in only 18 events were there simultaneous metre-wave spectral observations. All 28 absorption events have been identified as being associated with centimetre-wave outbursts. The solar radio events associated with polar cap absorption events are intense centimetre-wave burst radiations which have a very wide spectrum, extending down to metre-waves. The burst radiation on centimetre/waves is always partially polarized and it usually lasts more than 10 min.; in some cases several hours. Simultaneous dynamic-spectrum observations made in 18 cases on metre-waves show that in the majority of the cases they are associated with type IV radio emission. The details of the association of the polar cap absorption events with the solar radio outbursts are summarized in Table 1.

Table 1. Twenty-eight Polar Cap Absorption Events (August 1956–July 1959)

Associated centimetre-wave outbursts	Associated metre-wave outbursts		
	Type IV	Type II (No Type IV)	No spectral observations
28	15	3	10

Table 1 shows that all 28 polar cap absorption events are associated with centimetre-wave outbursts. Their peak intensities are comparable over the whole wave-length range of 3–30 cm.; the spectrum is rather flat in this wave-length range.

* Since the preparation of this article, a note on the same subject (*Nature*, **185**, 89; 1960) by Drs. A. R. Thompson and A. Maxwell came to our notice. These authors discuss the relation of low-energy cosmic rays with type IV metre-wave outbursts of continuum radiation, but do not consider the centimetre-wave outburst radiation which, as discussed in this article, plays a very important part in the occurrence of low-energy cosmic ray events.

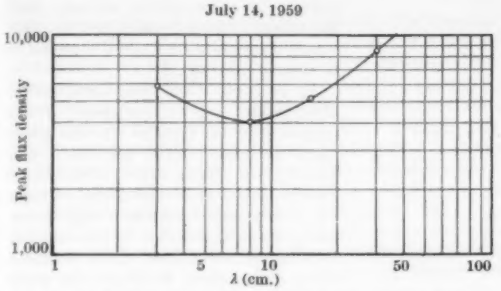

Fig. 1. Peak intensity ($\times 10^{-22}$ W.m.$^{-2}$ (c./s.)$^{-1}$) as a function of wave-length (cm.) during a broad-band centimetre-wave outburst associated with a polar cap absorption event

The spectrum of a typical outburst associated with an absorption event is shown in Fig. 1.

As shown in Table 1, nearly all the centimetre outbursts have type IV metre-wave emission associated with them. There are three cases in which the metre-wave event consists only of a group of type III bursts and a type II outburst without the appearance of a type IV event. Since there are reasons[5] for believing that centimetre-wave outbursts are emissions of type IV and that the type IV emission spectrum can sometimes have an abrupt low-frequency cut-off, one can assume that these three events are also type IV emission with peak intensity in the centimetre range.

As we have mentioned above, the polar cap absorption event follows the associated solar radio event with a delay varying from 1 to 50 hr. If we divide the centimetre outbursts according to their intensity into two classes, intense and moderate, we find that the average delay does not exceed 5 hr. for events associated with intense centimetre outbursts. For the moderate outbursts, the delay is greater. This result is summarized in Table 2.

Table 2 shows that the polar cap absorption event has a strong tendency to occur within 5 hr. of an intense centimetre-wave outburst. Statistically, the greater the intensity of the centimetre-wave outburst, the shorter the delay of the onset of the absorption event.

Thus, one can conclude that the polar cap absorption events are very closely associated with metre-wave continuum outbursts of type IV as well as broad-band centimetre-wave outbursts which are believed to be of the same nature as type IV emission on metre-waves. However, it is rather difficult to determine if all centimetre-wave outbursts will be associated with polar cap absorption events, since observations of polar cap absorption were not continuous until May 1958. Moreover, centimetre-wave dynamic-spectral observations will probably be necessary to determine if a particular centimetre outburst is the type associated with a polar cap absorption event and such observations have only just begun[5]. However, continuous observations of polar cap absorption since May 1958 are available, and some knowledge of the spectra of centimetre-wave outbursts can be obtained from single frequency measurements in the wave-length range of 3–30 cm.

We have analysed the centimetre-wave outbursts observed during the period May 1958–July 1959 in an attempt to determine the characteristics of centimetre-wave outbursts which are most likely to be associated with the polar cap absorption events. From our knowledge of the polar cap absorption events and the characteristics of the centimetre-wave outbursts associated with them, we have made a pre-selection of the outbursts used in our analysis. Thus, we have selected only the outbursts having a rather flat spectrum in the wave-length range of 3–30 cm. with peak intensities greater than 100 units over the entire range, and the duration of which is greater than 10 min. We have selected 34 such centimetre-wave outbursts. The association of these outbursts with the polar cap absorption events is shown in Table 3. Also shown in the same Table is the association between type IV metre-wave outbursts and the polar cap absorption events. It should be noted that metre-wave dynamic spectral observations were not available in all cases, and therefore we have used the single frequency observations on 200 Mc./s. to identify type IV emission in five cases.

Table 3 shows: (1) Only about one-third (35 per cent) of all centimetre-wave outbursts having peak intensities greater than 100 units over the wave-length range of 3–30 cm. are associated with polar cap absorption events. (2) About 83 per cent of intense broad-band centimetre-wave outbursts are associated with polar cap absorption events. (3) About 53 per cent of all type IV metre-wave outbursts are associated with polar cap absorption events.

Table 2. Centimetre-wave Events associated with Polar Cap Absorption Events

Centimetre-wave intensity class	Number of centimetre-wave outbursts	Number of associated metre-wave outbursts			Delay of polar cap absorption events	
		Type IV	Type II (No Type IV)	No spectral observations	< 5h	> 5h
Intense	16	10	2	4	13	3
Moderate	12	5	1	6	3	9

Table 3. Association of Radio Outbursts with Polar Cap Absorption Events (May 1958–July 1959)

Radio outbursts	Centimetre-wave intensity	No. of radio events	Polar cap absorption events		Percentage of polar cap absorption association
			Yes	No	
Broad-band centimetre-wave outbursts independent of metre-wave outbursts occurrence	intense and moderate	34	12	22	35
	intense only	12	10	2	83
Type IV metre-wave outbursts independent of centimetre-wave outbursts occurrence		19	10	9	53
Type IV metre-wave outbursts associated with broad-band centimetre-wave outbursts	moderate	7	0	7	0
	intense	12	10	2	83

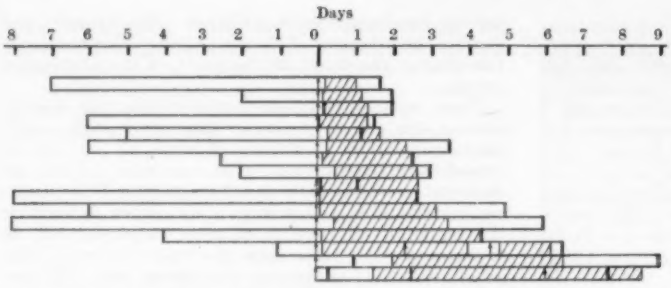

Fig. 2. Vertical arrow indicates the onset of broad-band centimetre-wave outburst or type IV event, double vertical lines indicate the appearance (left) and disappearance (right) of an active region of noise storms and hatched portions correspond, from top to bottom, to polar cap absorption events starting on Sept. 12, 1957; July 24, 1957; Sept. 26, 1957; July 29, 1958; Feb. 10, 1958; Sept. 21, 1957; July 14, 1959; Jan. 20, 1957; Sept. 22, 1958; Aug. 16, 1958; July 3, 1957; June 22, 1957; May 11, 1959; Aug. 20–Sept. 2, 1957; Mar. 25, 1958; Aug. 21–26, 1958

These outbursts are also associated with broad-band centimetre-wave outbursts, and therefore the association of the latter with polar cap absorption events increases from 35 to 53 per cent when type IV emission is associated with them. (4) Type IV metre-wave outbursts associated with moderate centimetre-wave outbursts are not associated with polar cap absorption events. (5) About 83 per cent of the type IV metre-wave outbursts associated with intense centimetre-wave outbursts are also associated with polar cap absorption events.

Thus, it follows that the intense broad-band centimetre-wave outbursts which are frequently associated with type IV metre-wave outbursts are the type of solar radio events most likely to be associated with polar cap absorption events. The occurrence of type IV outbursts on metre-waves alone is not a sufficient indication for the occurrence of polar cap absorption, but it must be simultaneous with intense centimetre-wave outbursts observed over the whole wave-length range of 3–30 cm. This result can be used in the prediction of the solar proton events. It should be noted, however, that the foregoing result is based upon limited results covering only 15 months, during which continuous observations of polar cap absorption were available.

It is known that broad-band centimetre-wave outbursts and type IV metre-wave outbursts of continuum radiation following solar flares do not last more than several hours, but the associated polar cap absorption can last several days. Also, balloon observations have detected the presence of protons up to several days after the associated solar event. The time-scale of the proton-induced polar cap absorption event is comparable to the duration of radio noise storms originating in active regions on the solar disk. We know that such noise storms occur only on metre waves and longer. A convenient source of daily records of radio-noise storms is given by the Nançay 169-Mc./s. interferometer observations which are displayed as 'active regions' on a diagram showing one-dimensional evolution of these regions[6]. On analysis, it is found that of the 27 polar cap absorption events, during which there were simultaneous interferometric observations, only seven (about 25 per cent) occurred during periods free of noise storms on 169 Mc./s. The remaining 20 events occurred during periods of enhanced 169-Mc./s. radiation. A graphical representation of the sequence of events—the 'active regions' of noise storms, the polar cap absorption events and the onset of broad-band centimetre-wave outbursts or type IV event—is shown in Fig. 2.

It is seen that the duration of the polar cap absorption event appears to be related to the presence of noise storm regions. The absorption starts after broad-band centimetre-wave outbursts or type IV event and continues approximately so long as the 'active region' is present. Further, there exists a close correlation between the presence on the Sun of the sources (determined by optically associated flares) where broad-band centimetre-wave outbursts or type IV events occur and the 'active regions' of noise storms[7].

The relation of the duration of the polar cap absorption events with the presence on the Sun of the 'active regions' of noise storms on 169 Mc./s. is more clearly seen from the two correlation diagrams shown in Fig. 3. In these diagrams, the duration of the polar

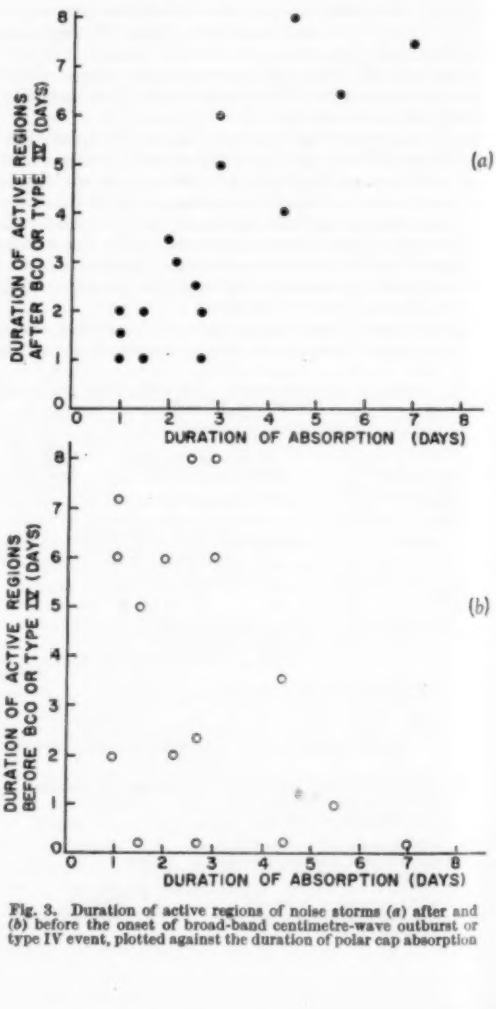
DURATION OF ACTIVE REGIONS AFTER BCO OR TYPE IV (DAYS)
(a)
DURATION OF ABSORPTION (DAYS)
DURATION OF ACTIVE REGIONS BEFORE BCO OR TYPE IV (DAYS)
(b)
DURATION OF ABSORPTION (DAYS)

Fig. 3. Duration of active regions of noise storms (*a*) after and (*b*) before the onset of broad-band centimetre-wave outburst or type IV event, plotted against the duration of polar cap absorption

cap absorption event is plotted against the duration of the 'active regions' of noise storms (*a*) after the occurrence of the broad-band centimetre-wave outbursts or type IV event (Fig. 3*a*), and (*b*) before the occurrence of the broad-band centimetre-wave outbursts or type IV event (Fig. 3*b*). Where more than one type IV event occurs during the presence on the Sun of the 'active regions', the total duration of all the polar cap absorption events is considered. It is evident from these two diagrams that the occurrence of a broad-band centimetre-wave outburst or type IV event is an important indication for the occurrence of a polar cap absorption event the duration of which appears to be related to the duration of the 'active regions' of noise storms after the broad-band centimetre-wave outburst or type IV event, but seems to have no relation at all to the presence of the 'active regions' before the onset of the broad-band centimetre-wave outburst or type IV event.

From the foregoing considerations it appears that the polar cap absorption events are very closely associated with the occurrence of broad-band centimetre-wave outbursts or type IV events and their duration is related to the presence on the Sun of 'active regions' of noise storms.

Thus, our results are consistent with the hypothesis that the cosmic ray particles, or fast protons, are accelerated by the same process as the fast electrons responsible for the emission of broad-band centimetre-wave outbursts or type IV continuum radiation. The presence of magnetic fields over the source of type IV emission, as evidenced by the strong polarization of the radio bursts, suggests the possibility of trapping of high-energy charged particles. The exact mechanism by which the protons accelerated during broad-band centimetre-wave outbursts or type IV emission are retained or generated in the solar atmosphere and gradually diffuse out of the Sun, with the gradual dissipation of magnetic fields, is not known. However, the fact that there is a close correlation between the presence on the Sun of the sources of broad-band centimetre-wave outbursts or type IV events, and of the 'active regions' of noise storms, on one hand, and between the duration of the polar cap absorption event and the duration of 'active regions' following the broad-band centimetre-wave outbursts or type IV events, on the other, suggest that these 'active regions' might play some part in the storage (or trapping) of the protons responsible for absorption events in the polar regions.

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SCINTILLATION COUNTING OF CARBON-14

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A PRECISE method for the radioassay of carbon-14 in aqueous solution was developed for use in work on the decomposition in soil of plant material labelled with carbon-14. This method is suitable for handling large numbers of samples with specific activities of 0·1–10 μc., and does not depend on the chemical form of the carbon or on the colour of the solution. The new method is a development of published methods[1–3] for the radioassay of weak β-emitters by counting the pulses of light emitted by a plastic phosphor in contact with a solution of the isotope.

A cell was made by cementing a disk of plastic phosphor (*N.E.* 102, 0·127 mm. thick, 4·12 cm. diameter, obtained from Nuclear Enterprises, Ltd.), on a disk of 'Perspex' (1·4 mm. thick, 4·12 cm. in diameter) using amyl acetate as solvent. A 'Perspex' ring (internal diameter 3·80 cm., height 2·50 cm., external diameter 4·12 cm.) was then cemented to the phosphor side of the combined disk. The cell fitted the counting chamber of a Panax model *S.C.–L.P.* scintillation counter, being held directly above the photomultiplier tube and in optical contact with it through a film of silicone oil. The radioactive solution was poured into the cell, placed in the counting chamber, and counted using a gain of 14,400, a discriminator voltage of 7·5, and with a voltage of 1,560 on the photomultiplier tube. The cell was then removed, rinsed with distilled water, dried with absorbent paper, and the next sample poured in. When the cell was exposed to strong light the background (32 c.p.m. at 25° C.) increased and returned to normal only after a number of hours. This effect was less marked the thinner the sheet of plastic phosphor; the cell described above could be handled in indirect light without significant rise in background count. An additional advantage in using a thin sheet of plastic phosphor is to decrease the normal background of the cell: a cell constructed with plastic phosphor 1·0 mm. in thickness had a background of 40 c.p.m. at 25° C. The volume of liquid required to cover the floor of the cell completely (4 ml.) covers the plastic phosphor to a depth of 3·5 mm., a depth much greater than the maximum range (0·3 mm.) of carbon-14 β-particles in water. For a given solution of carbon-14 the count rate should therefore be independent of the volume of liquid in the cell, once the floor of the cell had been completely covered. Fig. 1 shows that this was not so. This is because the amount of light reaching the photomultiplier by total internal reflexion at the liquid – air surface varies with depth. This effect was eliminated by adding an opaque dye to absorb all light transmitted through the solution, when the count rate becomes

independent of the volume of active solution for volumes greater than 6 ml. (Fig. 1). The count rate is reduced 10–12 per cent by loss of reflected light. Naphthalene leather carbon *G.S.* was a suitable dye for all the neutral and alkaline solutions tested; indian ink was suitable for solutions in which it did not coagulate. The amount of dye is not critical; a concentration of 0·1 per cent was normally used, but varying it from 0·05 to 0·15 per cent did not affect the result. Adding dye to solutions being counted makes it unnecessary to add an exact volume of an active solution to the cell, any volume between 6 and 18 ml. being suitable, and also makes it possible to count coloured solutions, because none of the light reaching the photomultiplier is transmitted through the liquid.

Fig. 2 shows that the count rate is directly proportional to the concentration of carbon-14 in aqueous sodium carbonate solutions, a result also obtained with aqueous solutions of sodium formate labelled with carbon-14. The counting efficiency of the cell depends on the volume of active solution in the cell; for a volume of 6 ml. the efficiency is 0·15 per cent, for a volume of 12 ml., 0·075 per cent. An estimate of the accuracy of the method was made by making two counts (approximately 75,000 each) on a solution of radioactive carbonate, emptying and cleaning the cell, doing another pair of counts on the same solution and repeating the emptying and filling of the cell ten times in all. The standard deviation between cell fillings was 0·5 per cent, within the pairs (statistical counting error) 0·4 per cent.

For accurate results all solutions counted must be homogeneous; when the active material precipitates or settles out high results are obtained, and the count rate rises with time. If the count rate increases the cell should be washed out, replaced in the counter and the background measured. If the background is then normal, sedimentation has occurred; if it has risen then another phenomenon, probably caused by incomplete quenching in the solution, is involved. This occurred with a few of the neutral solutions and all the acid solutions examined. For example, a 10 per cent sucrose solution containing 0·07 μc. labelled sodium formate/ml. gave a count of 2,101 c.p.m. rising to 2,825 c.p.m. in 10 min. When the sucrose solution was removed and the cell washed

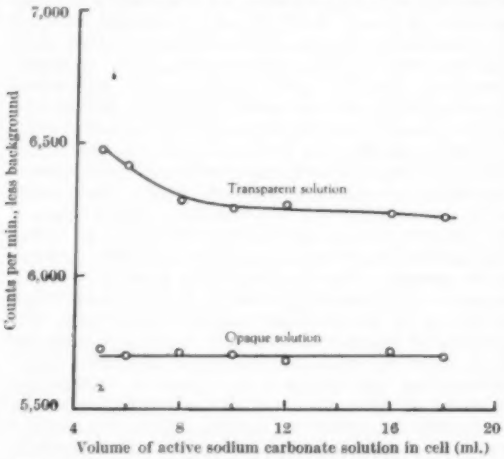

Fig. 1. Relationship between volume of active solution (0·29 μc./ml.) in cell and pulses counted

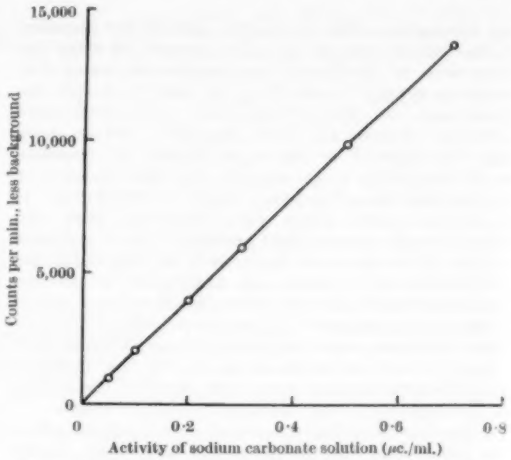

Fig. 2. Relationship between concentration of carbon-14 and pulses counted

and dried the background was 1,138 c.p.m., falling in 40 min. to 340 c.p.m. The effect is completely eliminated by adding alkali; a 10 per cent sucrose solution 0·1 molar with respect to sodium hydroxide containing 0·07 μc. formate/ml. gives a count of 1,478 c.p.m., the cell background being the same before and after counting. In counting solutions the behaviour of which has not been investigated it is best to make the solution 0·1 molar with sodium hydroxide as a routine procedure, because once the background count of the cell rises it takes 48 hr. to return to normal.

The range of β-particles in a liquid is affected by the presence of dissolved organic or inorganic material, particularly at high concentrations, and with materials containing heavy elements. The effect is small with materials containing light atoms; 10 per cent solutions of sucrose, sodium acetate, glycine and sodium hydroxide containing labelled formate or carbonate gave count rates differing by less than 5 per cent from those of aqueous solutions containing labelled sodium formate or carbonate alone. A 0·5 *N* sodium pyrophosphate extract of a compost and a 0·5 *N* sodium sulphite extract of the organic matter of a soil both containing labelled formate gave a count rate 4 per cent lower than the formate alone. Larger effects were obtained with solutions containing heavy metals; a 10 per cent solution of phosphotungstic acid made alkaline with sodium hydroxide depressed the count rate of a formate solution by 14 per cent. In accurate work this effect must be taken into account, either by the use of internal standards or by comparing activities in solutions as nearly identical in concentration and type of solute as possible.

The counting efficiency of this method is very low, but provided sufficient activity is available to give a convenient count rate it provides a very rapid and precise method for the radioassay of carbon-14.

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DEVELOPMENT OF RESISTANCE IN MICE TO TUMOUR INDUCTION BY *S E* POLYOMA VIRUS

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HYBRID (*C3Hf/Hen* × *AKR*)F_1 mice were highly susceptible to the induction of multiple types of neoplasms when inoculated, as newly born, with polyoma virus carried in tissue culture[1,2]. In more recent work, they were found to be resistant to the oncogenic effects of the virus after sublines had been carried for 3–13 serial passages in tissue cultures of Swiss mouse embryos, whereas Swiss mice retained full susceptibility to the virus. It thus appeared that while the virus had become adapted to the Swiss mouse by passage in Swiss mouse embryo cultures, it had lost its ability to infect the hybrids. This article reports the results of experiments performed to explore this possibility.

Tissue culture. Mouse embryo tissue cultures of Swiss or *C3H* mice were prepared by the method previously described[2,3]. Polyoma virus was carried in serial passage in Swiss mouse cultures in all experiments with the exception of one series where three sublines of the virus were carried simultaneously in both Swiss and *C3H/Hen* embryo cultures.

Virus. Nine sublines of virus were used. The origin of five (Nos. 3469, 60, 3919, 3607 and 3791) has been described[2,3]. The others (Nos. 5729, 5881 and 5884) were isolated from Swiss mice with parotid tumours induced by virus, while No. 695 was recovered from a hamster with sarcomas induced by virus. Sublines 5729, 5881, and 5884 were those carried simultaneously in both Swiss and *C3H/Hen* embryo cultures.

Mice. Some of the (*C3Hf/Hen* × *AKR*)F_1 litters were from mice bred in our laboratory. Others were obtained from the Animal Production Center of the National Institutes of Health, Bethesda, Md. The litters of Swiss mice were also from the Animal Production Center. The importance of these different sources of the experimental animals will be shown in this article. All mice were inoculated subcutaneously within 24 hr. of birth with 0·1 ml. of fluids from tissue cultures. The mice were observed for development of gross tumours, and those not developing neoplasms were killed 24 months after inoculation.

Immunological procedures. Mouse sera obtained by cardiac puncture were tested for the presence of neutralizing antibodies by a procedure described earlier[4,5], and by inhibition of virus hæmagglutinin[6]. Milk obtained from nursing mothers was also tested for antibody content by the inhibition of hæmagglutination of washed guinea pig erythrocytes.

To test for the inhibition of hæmagglutinin, twofold dilutions were made from the serum of individual mice ranging from 1/10 to 1/81,920. Each dilution was tested against two hæmagglutinating doses of the virus. Controls for the hæmagglutinating titres of the virus were made with each test. Milk was tested for antibodies by the same method.

Results. Polyoma virus sublines Nos. 3469 and 60 which were passed serially in Swiss mouse embryo cultures had produced tumours in (*C3Hf* × *AKR*)F_1 mice inoculated with passage virus through the ninth and eighth passages, respectively[2]. The hybrid mice receiving subline 60 showed a marked drop in susceptibility after the third passage[2]. The decline in response to subline 3469 was not so pronounced, but became obvious by the thirteenth passage under similar conditions. Three other sublines of virus also did not show oncogenic activity for the (*C3Hf* × *AKR*)F_1 mice but produced tumours in Swiss mice. These findings are shown in Table 1.

A possible explanation for the loss of oncogenic activity of polyoma virus for the hybrid mice was that the virus had become adapted to the Swiss mice because it was carried in tissue cultures of Swiss mouse embryos. To determine if this had occurred, virus sublines Nos. 5729, 5881 and 5884 were procured and grown simultaneously in both Swiss and *C3H/Hen* mouse embryo cultures from their first isolation and then tested for oncogenic activity in newly born Swiss and (*C3Hf* × *AKR*)F_1 hybrid mice. Table 2 shows that the hybrid mice were relatively resistant to the virus, although it had grown for 3–5 passages in cultures of strain *C3H* embryos. Such results

Table 1. COMPARISON OF SUSCEPTIBILITY OF (*C3Hf* × *AKR*)F_1 MICE AND SWISS MICE TO *S E* POLYOMA VIRUS
(Virus carried in Swiss mouse embryo cultures)

Virus subline	Passage	(*C3Hf* × *AKR*)F_1 mice		Swiss mice	
		Mice inoculated / Mice surviving	Per cent with tumours*	Mice inoculated / Mice surviving	Per cent with tumours
3469	13*A*	35/34	0·3	30/29	100
	15	6/6	0	—	—
	17	5/4	0	—	—
	18	11/8	0	—	—
	20	—	—	15/14	93
	21	4/4	0	9/9	100
60	10	8/6	0	80/74	93
3607	6*B*	4/4	50	7/7	100
	10*B*	17/13	0	—	—
	11*B*	8/7	0	8/6	100
3791	6	7/6	0	18/15	100
	8	16/16	0	32/22	95
	10	17/10	0	15/15	100
3919	2	4/4	0	—	—
	3	—	—	27/27	92
	6	6/5	0	22/19	100
	7	18/13	0	9/9	100
	8	10/10	0	—	—
	12	—	—	63/59	100
	24*b*	—	—	56/50	96
Pooled virus 3919 3791 3469	6 8 17	21/20	20	30/29	100

* Exclusive of leukæmia, which occurs spontaneously in these hybrids.

Table 2. Comparison of Oncogenic Activity on *S E* Polyoma Virus carried in Embryo Cultures of *C3H* Mice and of Swiss Mice

Virus subline	Virus passage	Mice	*C3H* mouse embryo		Swiss mouse embryo	
			No. inoculated / No. surviving	Per cent with tumours	No. inoculated / No. surviving	Per cent with tumours
5729	5	*C3Hf* × *AKR*	7/7	0	8/8	16
,,	5	Swiss	7/7	70	8/7	85
5881	3	*C3Hf* × *AKR*	6/6	16	6/6	32
,,	3	Swiss	8/8	100	7/7	100
5884	3	*C3Hf* × *AKR*	7/7	0	7/7	0
,,	3	Swiss	6/5	100	7/6	83

Table 3. Inhibition of *S E* Polyoma Virus Hæmagglutination by Specific Antibodies present in Strain *C3H* Mouse Milk*

Source of milk	Age of mice (months)	Milk dilutions							
		1/10	1/20	1/40	1/80	1/160	1/20,480	1/40,960	1/81,920
Two female mice inoculated with virus when newly born	5	—	—	—	—	—	—	±	3+
Two female mice from virus-free environment	6	—	—	—	3+	4+	4+	4+	4+
Cow's milk†	—	—	—	—	—	4+	4+	4+	4+

* Minus signs indicate complete inhibition of hæmagglutination. Plus signs preceded by numeral indicate degree of hæmagglutination.
† Calf serum has been shown to contain an inhibitor which prevents tumour induction in mice (ref. 7).

Table 4. Inhibition of *S E* Polyoma Virus Hæmagglutination by Mouse Serum Antibodies*

Mice	Age when bled (months)	Serum dilutions							
		1/80	1/320	1/1,280	1/2,560	1/5,120	1/20,480	1/40,960	1/81,920
Had virus inoculated when 4 weeks old	14	—	—	—	—	—	—	—	±
,, ,, ,,	14	—	—	—	—	—	—	±	3+
,, ,, ,,	14	—	—	—	—	—	4+	4+	4+
Not inoculated but kept in virus-contaminated environment	21	—	—	—	—	—	4+	4+	4+
,, ,, ,,	9	—	—	—	4+	4+	4+	4+	4+
,, ,, ,,	19	—	—	—	—	4+	4+	4+	4+
,, ,, ,,	19	—	—	4+	4+	4+	4+	4+	4+
,, ,, ,,	14	—	—	—	4+	4+	4+	4+	4+
With adrenal tumour graft 114G†	2	—	—	—	—	—	—	—	1+

* Sera of 12-month-old breeders from environment free of polyoma failed to inhibit hæmagglutination above 1/80 dilution.
† Transplanted tumour induced by virus carried through 114 serial transfers for period of 7 years.

show that growth of the virus in cultures of Swiss embryos was not responsible for its inability to infect the hybrids.

Resistance of the hybrid mice to polyoma virus was finally traced to maternal antibodies. Strain *C3H/Hen* female mice which were used as breeders and housed in the same room with mice that had received polyoma virus were found to have antibodies specific for the virus[5]. Their sera administered to newly born Swiss mice 1 hr. before receiving virus produced passive immunity. Tumour induction could also be prevented by mixing serum with virus prior to inoculation. Pooled sera from 12 breeders tested completely inhibited tumour induction in 100 per cent of 24 Swiss mice given sufficient virus to cause tumours in all of 16 mice that did not receive serum.

It was also found that the antibody could be transferred to the offspring by way of mother's milk. Milk taken from nursing strain *C3H* and Swiss mothers that had been exposed to the virus and from those not exposed when tested for antibody content by the method of inhibition of hæmagglutination showed pronounced differences in effectiveness. The results of a test are shown in Table 3. The range of antibody titres of pooled milk from exposed mice was similar to that observed in the sera of mice which had been exposed to virus (Table 4). The milk and sera from mice free of the virus showed a non-specific inhibition of hæmagglutination in titres of 1/40–1/80, while those with specific polyoma virus antibodies had titres of 1/1280–1/81,920. Since calf serum has been found to have a substance inhibitory for polyoma virus[7], cow's milk was also tested for hæmagglutination inhibition, but was found free of antibodies (Table 3).

Hybrid $(C3Hf \times AKR)F_1$ mice from animals bred in an environment free of polyoma virus were susceptible to the virus. Newly born litters of these hybrids injected with virus subline 695, 16th–18th passage in Swiss mouse embryo, developed the same spectrum of neoplasms (with the exception of mesotheliomas; it was previously reported that mesotheliomas were not observed in the hybrid mice) as did control Swiss mice. 83 per cent of 30 hybrid mice and 100 per cent of 27 Swiss mice developed neoplasms.

Polyoma virus has been shown to be highly antigenic. Serum antibodies specific for the virus have been found in the following animals: rabbits inoculated with virus for the purpose of developing immune sera[4]; mice inoculated when newly born which eventually developed neoplasms[5]; mice not injected with the virus but housed in an environment with inoculated animals[5]; suckling hamsters actively immunized with virus-antiserum vaccine[6].

Specific antibodies against polyoma virus have also been stimulated in adult female hamsters with

virus treated with formalin. The offspring of such animals when inoculated at less than 1–3 days of age developed fewer neoplasms, and the neoplasms appeared after a longer latent period than in the offspring of non-immunized females[9].

In a colony of mice with latent polyoma virus infection, transfer of maternal antibodies to the offspring by way of milk, as observed in our experiments, could account for any irregularity of results following inoculation of this virus. Maternal antibodies may also explain the lack of spontaneous parotid gland tumours in an infected colony. Antibodies transferred to the offspring could also explain the absence of these neoplasms in the offspring of tumour-bearing females (Stewart, S. E., unpublished work).

It is also conceivable that latent polyoma virus infections may become activated under certain conditions. Radiation has been reported as activating a latent leukæmia virus[10]. It is also possible that other carcinogens, viral or chemical, may produce tumours by the activation of this or other latent oncogenic viruses.

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AMINO-ACID COMPOSITION OF PROTEINS FROM SURFACE TISSUE OF THE TONGUE

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THIS investigation is part of a programme[1] to find a set of molecular properties which may serve as a parameter for predicting the tastes of compounds, and to learn the mechanism by which sapid substances stimulate the chemoreceptor taste organ. The fact that the tongue is practically the only taste-sensitive area indicates that there is something unique about its surface tissue. Since enzymes are involved in all biological processes and in view of the fact that optical isomers may have different tastes, thus revealing the stereospecificity of taste chemoreception, it is logical to examine first the protein material of the surface tissue of the tongue. It was thought that a knowledge of the amino-acid composition of the surface proteins might reveal the presence of unique amino-acids, or, if certain amino-acids are present in unusually large amounts, one could possibly get a clue to the type of molecular interaction occurring between the chemoreceptor and the sapid compound. In this study, the amino-acid composition was determined for the total proteins precipitated from the surface tissue of the tip of a human tongue.

Rectangular strips were removed from the outer surface of the tip, edges, and centre area of a human tongue. The underlying muscle and fatty tissue were scraped away, and the tough outer surface consisting of mucous membrane and papillæ was cut into very small pieces, and homogenized with 5 per cent trichloracetic acid in a Potter–Elvehjem-type tissue grinder. It was necessary to grind some of the very resistant tissue in a mortar. After centrifugation, the supernatant liquid was removed by suction. The precipitated protein was washed several times with 95 per cent ethyl alcohol, twice with acetone, centrifuged, and dried in a vacuum desiccator over concentrated sulphuric acid.

A 50-mgm. sample of this proteinic material was weighed and washed into a 50-ml. glass ampoule with constant boiling-point hydrochloric acid. The ampoule was evacuated, sealed, and heated for 24 hr. at 110 ± 2° C. to affect hydrolysis. 0·5 Ml. portions of the hydrolysate were placed in smaller ampoules and each sample dried in an evacuated desiccator over solid sodium hydroxide for 20 hr. The residue in each ampoule was dissolved in 0·5 ml. distilled water, then 0·5 ml. of 0·2 *M* sodium phosphate buffer *p*H 6·5 was added, and the solution was allowed to stand unstoppered for 4 hr. to oxidize any cysteine present to cystine. Then were added 0·03 ml. of freshly prepared 1 *N* hydrochloric acid and 2 ml. of 0·2 *N* sodium citrate buffer *p*H 2·2, containing *BRIJ*-35 and thiodiglycol. The ampoules were sealed and stored in a freezer for subsequent analysis.

'Amberlite *IR*-120' (*CG*-120) type II from the Rohm and Hass Co. was prepared by the Moore and Stein tap water modification[2] of Hamilton's[3] method of fractionating resins. Two fractions were taken for use, a 280-ml./min. fraction and a 580-ml./min. fraction. Columns of 150-cm. and 49-cm. lengths were prepared using 0·9-cm. inner-diameter tubes.

The 50° C. and the 30–50° C. systems of Moore and Stein were used with the long column. The short column was started at 30° and raised to 50° C. after the carnosine peak.

A synthetic mixture of amino-acids was prepared by adding 125 μmoles of the desired amino-acids to a 50-ml. volumetric flask half-filled with water plus 0·5 ml. of concentrated hydrochloric acid. The volume was brought up to 50 ml. and 2- or 3-ml. portions added to small ampoules. The air in each ampoule was replaced by nitrogen before sealing. The vessels were stored in a freezer until analysed. For analysis, 1 ml. of this solution of mixed amino-acids was diluted with 4 ml. of 0·2 *N* sodium citrate buffer *p*H 2·2 containing thioglycol and detergent solution. 2 Ml. of this solution, equivalent to 1 μmole of each amino-acid, was taken for analysis.

The volume at which each amino-acid was eluted, using a fraction collector, was determined from the contour of the resulting chromatograms and by comparison with the chromatograms of Moore and Stein. Then, the fraction number for the various amino-acids was used for determining the amino-acids present in the hydrolysates, and the sums of the absorbances at each peak were used for determining the quantities of each amino-acid present. Because of the small variations in the volumes used for releasing a given amino-acid from the column, the analysis of hydrolysates were checked by applying the chromatographic procedure to a 50-50 mixture of a synthetic sample and a sample from the protein hydrolysate.

Since tryptophan is destroyed during acid hydrolysis, it was determined by the spectrophotometric method of Goodwin and Morton[4].

Several runs were made on the protein material taken from the tip of the tongue. Typical chromatograms are shown in Figs. 1 and 2.

Lysine from the protein hydrolysate sometimes provided an asymmetrical peak. This raised the question as to whether or not ammonia accompanied the release of lysine from the column. Since the lysine peak from a synthetic mixture was also slightly asymmetric, it was concluded that this 'lysine' peak from the hydrolysate does represent lysine with no more than a trace of ammonia or some other contaminant.

In some runs, a rise in the base-line occurred where histidine would have been eluted. Because of the variable nature of the peak, it was not labelled as such. Even if this elusive peak, is histidine it corresponds to no more than 1·4 mgm. of amino-acid per 100 mgm. of dried protein.

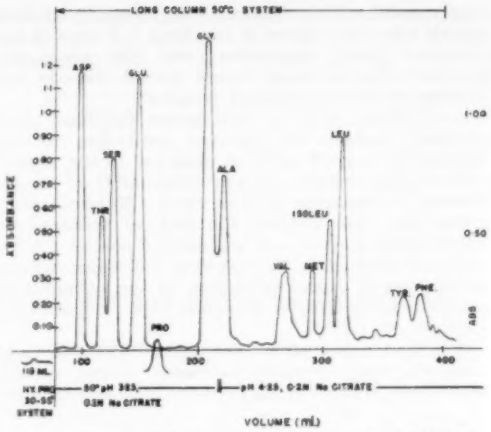

Fig. 1. Chromatogram of a hydrolysate of the precipitated proteins from the surface tissue of the tip of a tongue

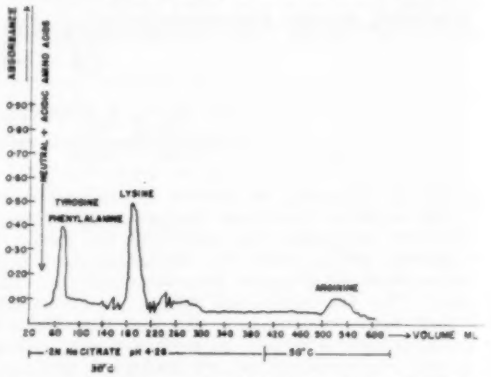

Fig. 2. Chromatogram of a hydrolysate of the precipitated proteins from the surface tissue of the tip of a tongue

Table 1. Amino-acid Composition of Precipitated Proteins from Human Tongue Surface Tissue in mgm. of Amino-acid per 100 mgm. of Protein

Amino-acid	Tip				Average value on tip area	Centre area
	1*a*	1*b*	II	III		
Glutamic acid	12·4	12·1	12·1	13·8	12·6	11·0
Lysine		15·2	7·6	12·2	11·7	14·6
Glycine	8·5	9·8	10·5	10·9	9·9	12·0
Aspartic acid			9·5	9·9	9·7	8·3
Leucine		7·0	7·2	7·9	7·2	6·4
Hydroxyproline	9·6	5·0			7·3	13·9
Alanine			6·2	6·9	6·6	6·7
Tyrosine plus phenylalanine		6·4	5·4	5·9	5·9	1·6
Valine	6·3	5·8	5·3	5·6	5·8	4·2
Arginine				4·3	4·3	5·4
Serine	3·9	3·8		5·4	4·4	
*Iso*leucine			3·6	4·4	4·0	3·5
Proline			3·6	4·2	3·9	5·9
Threonine	3·0	3·2		4·4	3·5	3·9
Tryptophan					(3·5)	
Methionine			3·4	3·2	3·3	1·9
Histidine						
Total					103·7	

Table 2. Amino-acid Compositions of Several Proteins in mgm. per 100 mgm. of Protein

Amino-acid	Horse hæmoglobin	Pepsin	Insulin	Beef tongue	Collagen	Tongue surface tissue (tip)
Alanine	7·4		4·5	6·4	9·4	6·6
Arginine	3·7	1·0	3·1	6·5	8·5	4·3
Aspartic acid	10·6	16·0	6·8	9·9	6·3	9·7
Cystine	1·0	2·1	12·5	1·3		0
Glutamic acid	8·2	11·9	18·6	17·0	11·3	12·6
Glycine	5·6	6·4	4·3	6·7	27·2	9·9
Histidine	8·7	0·9	4·9	2·5	0·8	?
Hydroxylysine					1·1	0
Hydroxyproline	0		0·0		14·0	7·3
*Iso*leucine	0·2	10·8	2·8	4·8		4·0
Leucine	15·2	10·4	13·2	7·8	5·6	7·2
Lysine	8·5	1·6	2·5	8·3	4·5	11·7
Methionine	1·0	1·7	0·3	2·2	0·8	3·3
Phenylalanine and tyrosine	10·7	14·9	21·1	7·3	3·5	5·9
Proline	8·5	5·0	2·5	5·6	15·1	3·9
Serine	5·8	12·2	5·2	4·7	3·5	4·4
Threonine	4·4	9·6	2·1	4·3	2·3	3·5
Tryptophan	1·7	2·4	0·3	1·2	0	3·5
Valine	9·0	7·1	7·8	5·1	3·4	5·8
Total	110	114	113	99·9	117	103·7

Occasionally other rises occurred in the base line absorbance. The base lines generally were not stable enough to attribute these fluctuations to amino-acids.

The computed amino-acid compositions of the protein material from the tip and centre areas of the surface tissue of the tongue are given in Table 1. In general, the ranges of values for a given amino-acid were not large, although there are two exceptions. Samples 1*a* and 1*b* represent two different analyses of the same batch of hydrolysate. One analysis was made on the precipitated proteins from the centre (bitter sensitive) area of the tongue. Little significance can be given to this single run, which was incomplete, because its reliability has not been determined through repeated analyses.

In Table 2 are listed amino-acid compositions of some other proteins for comparison. Since our work dealt with the mixture of proteins precipitated by trichloracetic acid, it is unlikely that a resemblance will be found with a single protein. It is observed, however, that the tongue surface proteins, unlike bulk beef tongue, contain no cystine, and are unique with collagen in having significant amounts of hydroxyproline. Tongue-surface proteins differ from collagen in that the former have tryptophan, a much smaller content of proline and glycine, and a higher percentage of lysine.

The work reported here should be carried further by first making a more refined sectioning of the tongue tissue to include only papillæ. Secondly, the tissue proteins should be fractionated and analyses made on homogeneous fractions.

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HIGH FREQUENCY OF SPONTANEOUS AND INDUCED SOMATIC SEGREGATION IN *ASPERGILLUS NIDULANS*

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THE ascomycete *Aspergillus nidulans* normally carries haploid nuclei in its hyphæ and produces vegetative spores (conidia) each with a single haploid (*n*) nucleus. Diploid nuclei arise spontaneously with a very low frequency by fusion of nuclei in the hyphæ. Such diploids can easily be selected and seem fairly stable. As a rare event mitotic crossing-over occurs and diploid segregants are produced, which show recombination for markers of a single chromosome arm[1]. This process seems to be analogous to that occurring in *Drosophila*[2]. The relative frequency of the different cross-over types is very constant and their absolute frequency low[3].

Besides mitotic cross-overs a variety of other mitotic segregants have been isolated from diploids. Recent results show that the types and frequencies which are observed depend to a high degree on the methods of selection and isolation. When standard methods of selection are used, two main further types of segregants, stable haploids and 'non-disjunctional' diploids, are isolated with frequencies usually lower than that of mitotic cross-overs. Special less-strongly selective methods, on the other hand, yield a large variety of *unstable* types, some with much higher frequency. These segregants vary in colony appearance, but they all have reduced growth-rate and viability, and are unable to compete with haploid or diploid colonies. Under favourable conditions, for example, when replated at low density, they all produce vigorous, stable sectors with apparently high frequency. The actual frequency of segregation may not be very high; but as soon as a few stable segregants are produced, these grow so much faster that they surround the unstable parental colony and stop its growth. Usually it is possible to harvest conidia from the centre of such colonies, which are still of the original unstable type and on replating show again the same pattern of segregating sectors.

It was found that any one unstable segregant produces either only haploid or only diploid sectors, except in rare cases when among the diploid sectors a fair proportion of haploid ones is found. All diploid sectors which show any recessive markers segregate simultaneously for all the markers on a chromosome, that is they are always of a 'non-disjunctional' type. The same mechanism of irregular segregation of whole chromosomes may therefore be responsible for the production of all unstable presumably aneuploid types as well as their stable haploid or diploid sectors. It would produce all mitotic segregants, except mitotic cross-overs. It is the aim of the present work to test this hypothesis.

Two methods of isolating segregants are used, which yield unstable segregants with high frequency. Preliminary results have been obtained using for analysis a diploid heterozygous for 19 markers on 7 out of 8 chromosome pairs. This diploid is wild type in phenotype with respect to all recessive markers, but if any mutant becomes homozygous or hemizygous the corresponding mutant phenotype is observed.

The first method of isolation is selective: single conidial heads, which show the mutant phenotype for recessive colour markers, are touched with a needle and the conidia sticking to it plated. This method yields many unstable segregants, which all give sectors of haploid type only. The haploid sectors of any one unstable segregant are identical with respect to most markers, but show segregation for the markers of a few chromosome pairs. The unstable segregant appears therefore as an aneuploid of a hyper-haploid type, and it is possible to deduce which chromosomes are monosomic and which disomic. As not all chromosomes were marked, only a minimal estimate of the chromosome number in any one aneuploid was obtained.

Table 1

Ploidy	Diploid	Aneuploid				Haploid
		$n+1$	$n+2$	$n+3$	Total	
Observed numbers	42	40	14	5	59	14
Frequency	37%				51%	12%

Among 115 segregants isolated in this way the frequency of the various ploidy types was as shown in Table 1 (ref. 4).

The second method is unselective and consists simply in plating random samples of conidia from different colonies of the original diploid on to complete medium. The density (conidia per plate) greatly influences the frequency of segregants recovered by this method. In a first set of platings with about 50 conidia per plate, segregant types were obtained with a frequency of 1/150, while in a second set with much lower density as many as 1/40 were observed. Different strains also may vary in the frequency of segregants produced. All colonies showing abnormal phenotype were classified as segregants and analysed by secondary platings. As all of them showed sectoring with high frequency they are assumed to be aneuploids.

The phenotypes of the different aneuploids vary and seem to fall into several types: (*a*) compact colonies; (*b*) colonies with poor conidiation and dark background colour; (*c*) very slow-growing, sometimes spidery thin colonies, which often are completely overgrown by segregating sectors. Among the last type about half of the aneuploids were found to be hyper-haploid often with at least $n + 3$ or $n + 4$ chromosomes. These hyper-haploids, which represent 10–20 per cent of the total number of aneuploids, produce only haploid sectors.

All other aneuploids produced diploid sectors, which in a high proportion were of parental genotype. It seems likely, therefore, that these aneuploids are of a hyper-diploid type. Besides parental diploid sectors, segregant diploid sectors were found in all cases, which were always of a 'non-disjunctional' type. The minimum number of extra chromosomes in these hyper-diploids could be deduced from the number of different 'non-disjunctional' types found among the diploid sectors. Most hyper-diploids seemed to be of the type $2n + 1$ and $2n + 2$. Some of these hyper-diploids also produce large haploid sectors, with much higher frequency than the parental diploid. Each one shows a distinctive pattern of segregation.

These results suggest that frequently in mitosis of diploid *A. nidulans* chromosomes are irregularly distributed, producing two nuclei of the types $2n + x$ and $2n - x$. So far the analysis of hyper-diploids ($2n + x$) suggests that x is usually small (1 or 2). This would explain why segregants 'non-disjunctional' for more than one chromosome have only very rarely been observed. As the $2n - 1$ or $2n - 2$ types which, according to this hypothesis, are produced have not been recovered with certainty, it has to be postulated that these types are often too unbalanced and short-lived to produce conidia, but that they produce by successive accidental loss of individual chromosomes more stable nuclei of smaller chromosome number. Haploids and 'non-disjunctionals' would then all arise as stable end-products of a secondary process of segregation in aneuploids.

If, on the other hand, aneuploids are produced by a chance distribution of chromosomes, x would have all possible values from 1 to 16 (accepting 8 as the haploid chromosome number[2]). As the types $2n + 3$ up to $4n$ have not been isolated, it would have to be assumed that they are either not present in conidia or produce colonies indistinguishable from the parental diploid. As a rare event this process would then produce a triploid and a haploid nucleus as originally postulated by Pontecorvo[1].

A further possible mechanism for production of haploids is genome segregation[6]. The observation of two cases of 'twin spots' makes it necessary to consider this process as an additional possibility. In both cases haploids of two types, complementary for all 16 distinguishable markers, were recovered from a single head. But in one case the number of colonies obtained was very small; in the other, aneuploid types were present in addition to the complementary haploid types. Obviously further information is needed to decide whether genome segregation occurs.

Two new diploids have now been developed with markers on practically all chromosomes of the eight pairs, mostly in repulsion in one diploid, mostly in coupling in the other. It is hoped that they will provide conclusive evidence as to whether one or several types of mitotic segregations are producing haploids in diploid fungus strains.

Some observations on effects of high doses of X-rays on mitotic segregation in another heterozygous diploid have been obtained recently[7]. It was found that at a dose of about 50,000 r. none of the surviving conidia is of the parental type. The few strains with normal growth-rate and phenotype carry recessive lethals and reciprocal translocations which change the pattern of mitotic segregation, but do not increase its frequency. But the majority of survivors grow very slowly and show a high frequency of segregant sectors, often of a haploid type only. Some unstable, fairly well-growing strains, giving diploid sectors comparable to those found in spontaneous hyper-diploid strains, have also been obtained. In all cases the segregation seems to involve whole chromosomes and appears to be the same mechanism as that observed in spontaneous mitotic segregation. But much more detailed analysis using diploids containing many more chromosomes marked on both arms is needed for a conclusive comparison of spontaneous and induced mitotic segregation.

The segregation found in *Aspergillus nidulans* is parallel in most details to that observed in *Penicillium chrysogenum*, where unstable segregants are obtained after treatment with X-rays[8] or nitrogen mustard[9]. Aneuploidy has been rejected as an explanation of the results in *Penicillium*, because only aneuploids of a hyper-haploid type were considered, but it seems that these new results can provide a good explanation of most observed features of the induced 'high-frequency-segregation' described in *Penicillium*. Unfortunately the number of markers used in the *Penicillium* diploids is too small, and the mutagenic treatment too drastic, to permit detailed comparison and really safe conclusions.

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LETTERS TO THE EDITORS

ASTRONOMY

Dirac's Cosmology and the Origin of the Solar System

In one of his earlier papers, Dirac[1] concluded that the gravity coefficient, far from being constant, varies inversely with a "universe time parameter". This result was not accepted by the physicists and it was common opinion that a field theory featuring a non-constant gravity coefficient falls outside the limits of the general theory of relativity. However, Dirac's idea was revived recently. Starting from reasonable assumptions, C. Gilbert[2] showed, in 1956, that Dirac's hypothesis is a corollary of the general theory of relativity. He further computed the age of the universe from the present value of the gravity constant and found it to be $4{\cdot}1 \times 10^9$ years, in remarkable coincidence with the age of the Earth of $4{\cdot}2 \times 10^9$ years, as determined by radioactive methods.

I wish to put forward an apparently acceptable hypothesis of the origin of the solar system, based on the results of Dirac and Gilbert.

Let us consider the state when t, the universe time parameter, was quite small, and let us assume that the mass of the solar system was at that time concentrated in the Sun. Because of the relation $f = x/t$, gravity acceleration in the Sun must have been very great, resulting in large-scale pressure-dependent degeneration of matter. Therefore, the radius of the Sun must have been very small and its angular velocity must have been several times as great as at present.

The centrifugal force and gravitational acceleration on the solar equator have, however, steadily decreased. In the case of gravity acceleration, this was due partly to the decrease of $f = x/t$ and partly to the resulting increase of the solar radius. The increase of radius is considered to have been at first a linear function of universe time, so that:

$$g_s = \frac{xM}{t\,(r_0 + \alpha t)^2}$$

M being the mass of the Sun, and g_s the gravitational acceleration on the solar surface.

However, the impulse momentum of a rotating Sun is given by:

$$\omega \Sigma m_i r_i^2 = \lambda = \text{constant}$$

giving for the solar equator a centrifugal force:

$$r\omega^2 = \frac{r\lambda^2}{(\Sigma m_i r_i^2)^2} = \frac{A}{(r_0 + \alpha t)^3}$$

Comparing the gravity acceleration with the centrifugal force, it is apparent that the two terms will vary, when disregarding the coefficient $\frac{1}{(r_0 + \alpha t)^2}$, according to the functions $\frac{A}{r_0 + \alpha t}$ and $\frac{B}{t}$ respectively. The graphs of the two functions are shown in Fig. 1. In case $A - \alpha B > 0$, there will be an instant t_1 when the centrifugal force becomes equal to the attraction of gravity on the solar equator, so that part of the solar mass can escape into the universe. The molecular forces could inhibit escape temporarily. Escape took place when the weightless mass formed a planet in consequence of its own gravitational attraction.

This escape of mass will result in a decrease of the solar radius and a consequent decrease of centrifugal force on the surface of the remnant Sun. On the other hand, the gravitational acceleration will be greater because of the smaller radius. Therefore the play of forces will be repeated. Fig. 1 shows that after a number of repetitions—at steadily growing time intervals—the centrifugal force will no longer be capable of equalling the force of gravity. (In tracing the diagram the simplifying assumption was made that the discontinuous increase and decrease of the two quantities involved takes place in steps of equal size.)

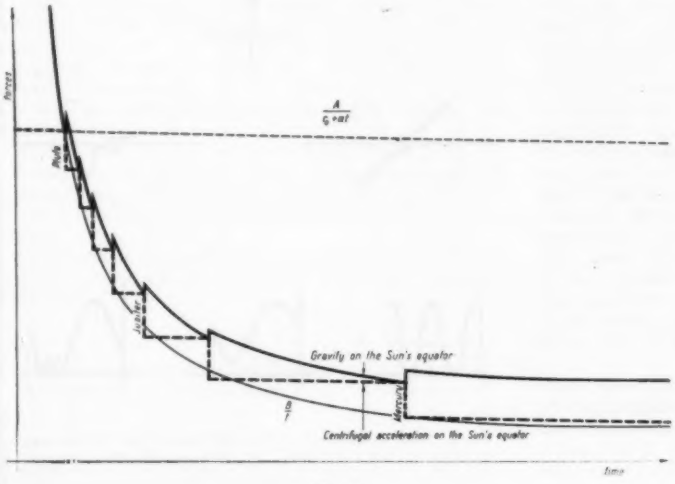

Fig. 1

The escaped masses will, because of the decrease of f, rotate on steadily widening orbits, since fR must be a constant, R being the orbital radius in question.

Therefore, the following equation is valid:

$$\frac{r_n}{t_n} = \frac{R_n}{t}$$

that is:

$$R_n = \frac{r_n t}{t_n} = \frac{r_0 + \alpha t_n}{t_n} \cdot t = \left(\frac{r_0}{t_n} + \alpha\right) t$$

where R_n is the actual orbital radius, r_0 the orbital radius at the moment of formation, that is, at the time t_n.

The graph indicates that the value t_n is—at least within a certain time interval—roughly twice the preceding value, so that:

$$R_n = \left(\frac{r_0}{2n t_0} + \alpha\right) t = \frac{C}{2^n} + D$$

in agreement with the 'law' of Titius and Bode.

The masses escaping from the Sun will invariably be those of highest specific impulse momentum. Thus it can be understood why the bulk of the impulse momentum of the solar system is borne by the planets.

Gravity differentiation in the Sun must have been most intense at the time when gravitational acceleration was greatest. Therefore, the older, that is, the outer, planets are of smaller bulk density.

The above mechanism can be extended to the satellites of the larger planets, too. The coincidence of the orbital planes is a matter-of-fact corollary and the formation of rings or asteroids is also possible.

This theory is obviously far from being complete. I wish merely to show that the results obtained by Dirac and by Gilbert may in themselves be the nucleus of a theory of the origin of the solar system.

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The Extragalactic Distance Scale

The establishment of the scale of distances in the extragalactic universe rests primarily on the determinations of the distances of the nearest galaxies. These distances have been obtained primarily from a comparison of apparent magnitudes of variable stars or of Population II giants with the known absolute magnitudes of such objects measured in our Galaxy.

Arp[1] has obtained colour-magnitude diagrams for four clusters in the Small Magellanic Cloud and has found that these diagrams are different from colour-magnitude diagrams of similar objects in the Galaxy. Using a faint sequence of magnitudes lent to me by Arp, I have obtained colour-magnitude diagrams for six clusters of the Large Magellanic Cloud and have found that the diagrams differ not only from those found in the Galaxy but also from those found by Arp in the Small Magellanic Cloud. Three of those studied by me are globular clusters: *NGC* 1846, *NGC* 1978, and Anonymous 4. Their giant branches have slopes much more gentle than any observed in globular clusters of our Galaxy. Even the giant branch of *NGC* 6356, which Sandage and Wallerstein[2] find to have an unusually gentle slope, is steeper than those in the clusters of the Large Cloud.

NGC 1831 and *NGC* 1818, two of the three other clusters, are similar in appearance to globular clusters, but are much younger, with colour-magnitude diagrams somewhat similar to those of *M* 11[3] and *h* and χ Persei[4], respectively. They differ from open clusters of our Galaxy not only in their much larger numbers of stars but also in the unexpected location of the giants in their colour-magnitude diagrams. The sixth cluster, *NGC* 1844, a small open cluster, shares this latter peculiarity. *NGC* 1844 has a main sequence similar to that of *NGC* 4755[5], but its giant stars are bluer and brighter.

Because the distances to the nearby galaxies are determined from the apparent magnitudes of the giant evolved stars such as the Cepheids, the *RR* Lyrae variables, and the brightest stars of Population II, the evidence presented by the Magellanic Clouds indicates that these distances are not necessarily correct. The characteristics of the giant stars, and their evolutionary paths, appear to differ in different galaxies and we may not safely use their apparent magnitudes as an index of distance until we thoroughly understand these differences.

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April 6.

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RADIOPHYSICS

Faraday Effect in the Transmissions from Fast Spinning Satellites

The interaction of the satellite spin and the Faraday rotation effect in the ionosphere in producing polarization fading in linearly polarized signals from Earth satellites has been discussed for the case when the satellite rotation period is of the same order as the Faraday fading period[1,2]. In this case, determination of the rate of Faraday fading is difficult unless simultaneous fading records on two frequencies can be taken.

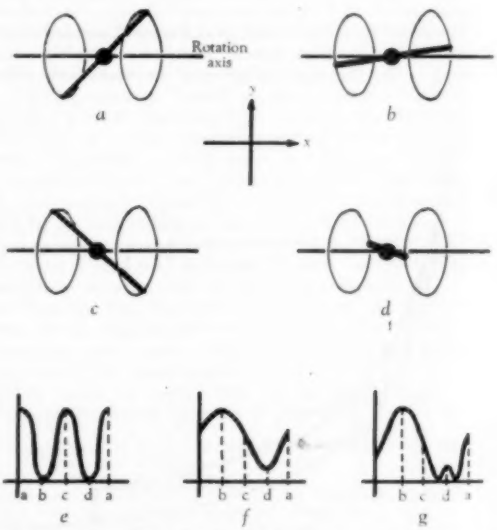

Fig. 1. Four positions of a dipole with its rotation axis and axis of symmetry not coincident. The corresponding signal strength variations for polarizations in the x and y directions are shown at f and e when the line of sight is outside the generated cone, and at g and e when it is inside

The effect of the interaction of satellite spin and Faraday rotation is different for transmissions from a satellite with a rotation period small compared to the Faraday fading period. Consider such a satellite rotating about an axis fixed in space with a transmitting dipole which is not coincident with the rotation axis. As the satellite rotates, the dipole generates a cone, as shown in Fig. 1. Consider the case when the line of propagation is outside this cone. In the absence of Faraday rotation, a receiving aerial with its line of polarization in the x-direction would receive maximum signal strength when the satellite dipole is in the position shown at b and minimum signal strength in the position shown at d. A similar aerial polarized in the y-direction would receive maximum signal strength with the satellite dipole in positions shown at a and c and minimum in positions shown at b and d. These expected signal strength variations over one rotation period are shown in Fig. 1 at e and f. If the line of propagation is inside the generated cone, the variation in the y direction of polarization is somewhat different (Fig. 1g).

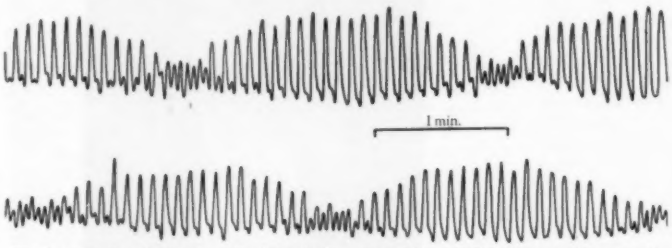

Fig. 2. Variations in the strength of signals from the satellite 1958β2 (*Vanguard I*) received simultaneously on two orthogonally polarized aerials (Feb. 4, 1960)

The effect of 90° of Faraday rotation in the ionosphere would be to interchange the types of variation in the x and y directions of polarization. Changes of a quarter-turn in the amount of Faraday rotation during a satellite passage will thus result in the signal strength variations received on a linearly polarized aerial alternating between types e and f or e and g of Fig. 1.

Records of the 108 Mc./s. signals of 1958β2 (*Vanguard I*) taken on orthogonally polarized aerial arrays show this type of fading (Fig. 2). The rotation period is about 6 sec. and the Faraday fading period is normally greater than 30 sec. The points on the record corresponding to the variation in Fig. 1e are well defined and their times can usually be determined to within ± 3 sec.

Such records taken at the Jodrell Bank Experimental Station over the past nine months are at present being analysed to determine ionospheric electron contents from the observed rates of Faraday fading.

This work is supported by a grant from the Royal Society. One of us (R. S. R.) holds an Athlone Fellowship.

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Jodrell Bank Experimental Station
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Macclesfield. April 8.

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Electron Density Measurements in the Upper Ionosphere using the Faraday Rotation of Radio Signals from Artificial Satellites

Several workers have used the Faraday rotation of radio signals from artificial satellites as a means of investigating the upper ionosphere, and in most cases it has been assumed that the ionosphere is spherically stratified.

Observations made at Cambridge on 1957α2 and 1958β2 have shown that the variation of the ionosphere with latitude and longitude must be taken into account for satellite passes near or below the peak of the $F2$ layer, if results consistent with vertical incidence soundings are to be obtained. It was found that a sufficiently accurate estimate of this variation could be obtained from hourly ionograms taken at Slough and Inverness.

The effect of the horizontal variation of the ionosphere in a particular case is shown in Fig. 1. On this

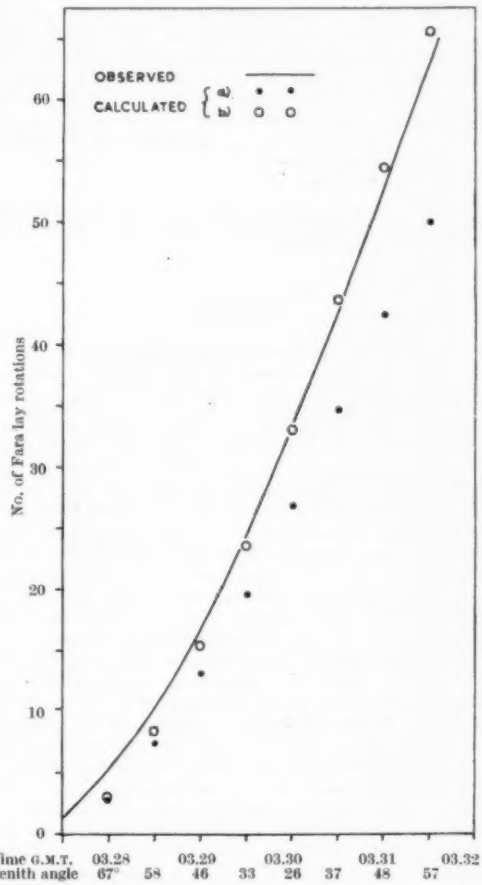

Fig. 1. 20 Mc./s. Faraday rotation, 1957α2/*Sputnik* I, 20/10/57

occasion the satellite was slightly above the *F*2 layer peak at closest approach, so that the profile assumed for the layer above the peak has little effect on the calculated rotation curve.

The points (*a*) were calculated assuming spherical stratification of the ionosphere, using the electron density profile deduced from the Slough ionograms up to the peak, and a semi-parabolic distribution above it. The points (*b*) were calculated from the same electron density profile taking account of the horizontal variation estimated from the Slough and Inverness ionograms. The improved agreement with the observed rotation curve in case (*b*) is quite marked.

Several records of satellite passes well above the *F*2 peak have been analysed, making due allowance for the horizontal variations in the ionosphere as deduced from ionograms, and it has been found that self-consistent results can be obtained from a very simple model of the upper ionosphere. These results are as follow.

Above the *F*2 layer peak the electron density falls off with a scale-height of approximately 230 km., which is of the same order as that found by Bowles[1], and the average ratio of the total electron content above the peak to that below is 3·4 to 1, which agrees well with measurements made by the Moon-echo technique, and measurements using the radio rise and set of artificial satellites by Al'pert *et al.*[2].

Observations made during an ionosphere storm showed a considerable decrease in the total electron content up to the satellite, with little apparent change in the ratio of the contents above and below the peak.

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PHYSICS

Growth of Surface Instabilities in a Linear Pinched Discharge

Recent experiments at the Imperial College of Science and Technology, London, have been concerned with the growth of instabilities in a linear pinched discharge in argon. These discharges were produced in a tube 15 cm. in diameter and 50 cm. long at pressures of 0·1–1 mm. mercury and with currents of 40–150 k.amp. The experiments have revealed the presence of surface instabilities of the type shown in Fig. 1, which is typical of many single-shot photographs of the discharge taken through the side of the tube with a Kerr cell camera. The irregularities on the plasma surface first appear when the column is expanding from the first axial bounce, and grow while the plasma is being accelerated towards the axis of the discharge tube between the first and second 'bounces'. In Fig. 2 the diameter of the column, together with the amplitude of the instability, and its mean wave-length, are shown as functions of time for a particular set of initial conditions. In this diagram the diameter of the column has been found by taking the mean of fifty measurements of the local diameter at different points along the tube axis. A numerical estimate of the amount of instability was obtained from the

Fig. 1. *C*, 1,900 μF.; V_c, 5·0 kV.; *L*, 300 mμH.; *p*, 330μ. Photograph taken with exposure of 0·4 μsec., 18 μsec. after first pinch

standard deviation of these measurements about their mean.

It is suggested that these instabilities are associated with the acceleration of the plasma boundary and are analogous to the Rayleigh–Taylor instabilities[1,2] found when a heavy incompressible fluid is supported against gravity by a lighter one. In the plasma case the magnetic field behaves as the lighter fluid, and the instability grows, as expected, when the plasma is being accelerated by the field.

For plane surfaces the growth should be exponential of the form $\exp(\omega t)$, where the growth-rate ω is given

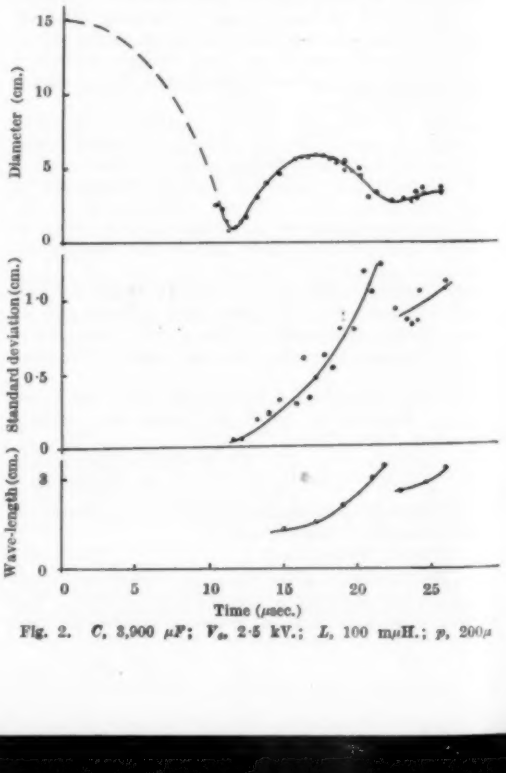

Fig. 2. *C*, 3,900 μF; V_c, 2·5 kV.; *L*, 100 mμH.; *p*, 200μ

by $\omega^2 = gk$, g being the acceleration and k the wave number ($2\pi/\lambda$) of the disturbance.

Under various initial conditions the measured accelerations and observed wave-lengths allow the growth-rates to be calculated. The values obtained experimentally from the standard deviation curves are about a factor of two smaller than those expected from the above expression. The finite compressibility of the plasma and the cylindrical geometry of the discharge system have not been taken into account and may well influence the numerical comparison.

When dissipative processes such as viscosity[3-5] and resistivity[6], or effects of finite amplitudes[7], are included in the analysis a dominant wave-length should occur. Our experiments suggest that the plasma viscosity is too small to explain the observed wave-lengths.

In the interpretation of the present experiments it has not been found necessary to allow for the growth-rate of $m = 0$ instabilities arising on a steady-state configuration[8-11]. It is suggested that this results from the fact that a likely perturbation will not be axisymmetric in the early stages of growth. In this case the plasma will be either stable or in neutral equilibrium as the increase in B_θ normally associated with a local decrease in r (and vice versa) will not occur.

The shape of the boundary as shown in Fig. 1 is very similar to that observed experimentally[12] for the Rayleigh–Taylor instabilities in fluids, having a rounded convex surface towards the plasma and cusps projecting into the magnetic field.

A detailed account of this work will be published elsewhere.

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Use of an Auxiliary Grid to stabilize the Gain of a Photomultiplier

We have recently examined the possibility of reducing the sensitivity of a photomultiplier to changes in supply voltage by means of feedback to an auxiliary grid.

An eleven-stage tube (Electrical and Musical Industries type 6097) was provided with a grid between cathode and first dynode through the co-operation of the manufacturers. The dynodes were connected to one another and to the cathode by the usual resistor chain. Instead of grounding the cathode directly, however, it was connected to Earth through a feedback resistor, normally of the order of some thousands of ohms. An appropriate d.c. bias of the order of a few volts was applied to the grid.

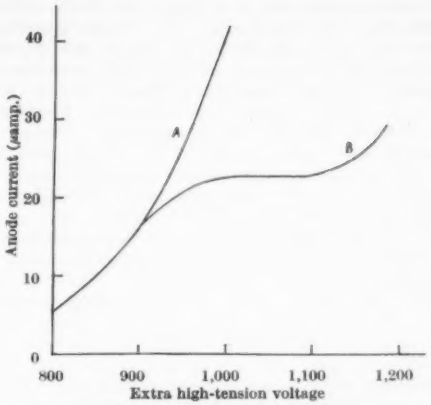

Fig. 1. Direct-current operation

A definite fraction of any variation in the extra high-tension supply voltage is thus fed back to the cathode and hence effectively to the grid, with the result that the anode current can be maintained substantially constant.

Fig. 1 shows how, under conditions of constant cathode illumination, the anode current of the photomultiplier varies with extra high-tension voltage, *A* when the tube is used conventionally with the grid strapped to the cathode, and *B* with feedback present. It can be seen that quite an appreciable plateau exists. The voltage at which the plateau appears can be shown, both theoretically and experimentally, to be inversely proportional to the value of the feedback resistor. The d.c. bias which must be applied to the grid is found to be effectively constant over a wide range of extra high-tension voltages.

To test the performance of the tube for pulse work it was used as a gamma-ray spectrometer in conjunction with a sodium iodide crystal, low-gain amplifier and single-channel analyser. Curves *C* and *D* of Fig. 2 show how the position of the cæsium-137 photopeak shifts when the extra high-tension voltage is changed from 890 to 980 volts with the tube used conventionally. Curves *E* and *F* were obtained with feedback present and show how the position of the photopeak remains practically unaltered as the extra high-tension voltage is changed from 1,040 to 1,140 volts.

One would expect that the resolution of the peak would worsen with the introduction of feedback,

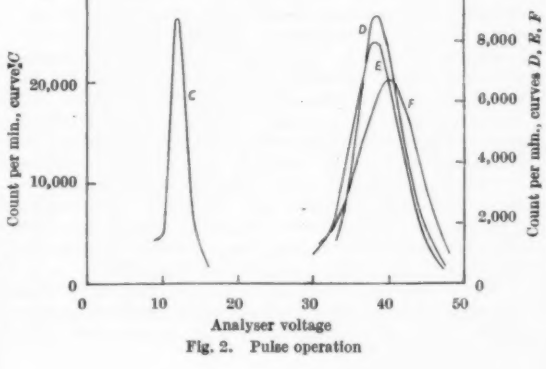

Fig. 2. Pulse operation

since this is equivalent to a reduction of the cathode sensitivity. The value for the cathode sensitivity for the tube used was 26 μamp./lumen, and for this value one would expect under ideal conditions a resolution of about 10 per cent. Due to the fact that neither the tube, crystal nor associated electronics were specially selected for spectrometry, the actual resolution was found to be 17 per cent, when the tube was used conventionally. With feedback the resolution worsened to 20 per cent at one end of the plateau and 24 per cent at the other for the curves of Fig. 2. While this is obviously unsatisfactory, it must be remembered that at the cathode sensitivity of 26 μamp./lumen of the present tube, the resolution worsens very rapidly with decreased cathode sensitivity[1]. With a tube of, say, 100 μamp./lumen sensitivity the resolution varies only slowly with cathode sensitivity, and the introduction of feedback should make little or no difference to it.

In conclusion, it should be remarked that the stability of the feedback resistor chain and to a lesser extent of the bias battery must be of a high order. This, however, is a small price to pay if a relatively simple power supply may be used in place of the ultra-stable supplies at present required for precision work.

It is hoped to publish a fuller account of this work in the near future.

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Coherence and Band-width of a Gas Discharge Harmonic Generator

Recent work has shown that a microwave gas discharge is an efficient harmonic generator[1–3]. These results are of interest since they show promise of producing a reasonable quantity of power in the 1-mm. wave-length region. This would be extremely useful for spectroscopy, especially if the radiation were narrow-band and coherent. Two experiments have been performed to see whether this is so.

Fig. 1 is a diagram of the first experiment, designed to measure coherence. The two harmonic generators were simple neon-filled discharge tubes in wave-guide mounts as previously described[3]. The gas discharge was maintained in both tubes by power from a 2 kW. 3-cm. klystron amplifier, arranged to give pulses of 3-m.sec. duration. By suitable tuning of the discharge tube mounts the fourth harmonic (in the 8-mm. band) was selected. It was passed through low-Q wave-meters to remove other harmonics present. The two 8-mm. band signals were combined in the magic-T and fed to a single crystal detector. By adjusting the 8-mm. wave-guide attenuator and phase shifter a minimum in the output signal could be maintained. This was less than 0·25 mV. across the crystal detector. The corresponding maximum when the two signals were added in phase (by adjusting the phase shifter to give a maximum with the attenuators unaltered) was 50 mV. Hence the coherent signal/noise ratio was at least 100/1.

This cancellation experiment also indicated that the signal was narrow-band since the length of 8-mm. guide before the magic-T made the system dispersive. The second experiment confirmed this. The output from one of the harmonic generators was fed into an 8-mm. superhet receiver. The local oscillator frequency was swept so that the input spectrum could be displayed on a cathode-ray oscillograph. This gave a pulse 1 Mc./s. wide which corresponded closely to the measured intermediate frequency band-width of the receiver. Hence the band-width of the signal was less than 1 Mc./s.

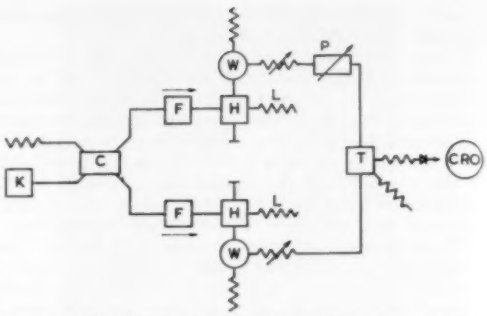

Fig. 1. Block diagram of the experimental apparatus. K, 2-kW. X-band klystron; C, 3 d.b. directional coupler; F, X-band ferrite isolator; H, harmonic generator; L, X-band water load; W, low Q wave-meter (Q-band); T, magic-T; P, phase shifter

These experiments show that the harmonic generator output is coherent and narrow-band. It is a true line source comparable to a reflex klystron.

We wish to acknowledge the advice and encouragement of Mr. I. M. Ross and Dr. H. Motz during the course of this work. In so far as two of us (N. R. B. and D. W.) are concerned, this work was sponsored in part by U.S. Air Force contract No. *AF* 61 (514)-1183 and for the participation of the third (J. C. V.) this work is published by permission of the Admiralty.

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Transistor Modulators for Low-level Direct Current Signals

We have considered in some detail the problem of using germanium and silicon transistors as choppers in thermocouple-amplifier and other low- and medium-impedance applications. In the past, several circuits have been described using asymmetrical transistors with switching drives which are symmetrical or asymmetrical with respect to the emitter and collector of the transistor. Many of these circuits require careful adjustment and/or selection of transistors to reduce the equivalent input drift with temperature to an acceptable level.

A circuit has been developed in our laboratories, in which a symmetrical transistor is used with a symmetrical drive, giving drift-rates of not greater than 1·5 μV./° C. over a temperature-range of −40° C. to + 100° C. with no adjustment or selection whatsoever.

This has been made possible by the development by Semiconductors, Ltd., of a symmetrical silicon alloy transistor to our specification. This is at present an experimental type, but is available in limited quantities.

It is hoped that it will be possible to publish a full account of this work in due course.

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ENGINEERING

A Systematic Method for the Construction of Error-correcting Group Codes

Slepian[1] has pointed out that all systematic binary codes of length n form a sub-group of the group of all binary words of length n. The problem of choosing a systematic code for correcting a given set of errors is thus equivalent to finding a sub-group such that each error to be corrected for lies in separate cosets. Fire[2] has pointed out that the sum modulo 2 of two parity check sequences corresponding to two error patterns is the same as the parity check sequence corresponding to the sum modulo 2 of the same two error patterns. Also, each parity check sequence is uniquely associated with one coset. This sets up an isomorphism between the group of parity check sequences and the quotient group of the code group in the group of all words.

This consideration has led to a systematic method of generating group codes for correcting an arbitrary set of errors. The method has been applied to the generation of maximal two-error correcting codes of length 5–11, which coincides with the groups indicated by Slepian. The method is as follows: (1) Choose a set A of linearly independent error patterns which span the set of all 'allowable' error patterns, that is, error patterns to be corrected. (2) Choose two arbitrary parity check sequences to represent the first two of this set A of error patterns. Let us call this set of sequences B. (3) By modulo-two addition of members of B, generate the set of parity check sequences of all error patterns spanned by B. (4) Write down all parity check sequences so generated as well as the modulo-2 sums of those pairs of parity check sequences at least one of which forms an allowable error pattern by addition-modulo two with the next member of A. (5) Choose a parity check sequence outside the set generated in step (4) to represent the next error pattern in A and append this to the set B. (6) Repeat steps (3), (4) and (5) until all possible error patterns have been spanned.

In the case of the two-error correcting code mentioned earlier, the set A may be conveniently chosen as the set of all single errors, and the initial two parity check sequences can be conveniently chosen as the binary 1 and 2, that is, 000 . . . 01 and 000 . . . 10.

In this case step (4) simply reads: (4), Write down all parity check sequences of double errors generated by the single errors in B as well as the sum modulo 2 of pairs of these parity check sequences at least one of which is a single error parity check sequence. It may be interesting to record that the time taken to generate all two-error correcting codes of 5–11 bits long was 4 hr. by hand.

I am at present setting up a computer programme to generate the parity check sequences for longer blocks of binary digits. After getting the parity check sequences, it is a simple matter to generate the group codes and parity check rules.

I expect to publish the results of the computer data with a more detailed description of the method and its theoretical basis elsewhere.

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MINERALOGY

Predehydroxylation State of Kaolinite

The loss of water of constitution from kaolinite with increasing temperature under atmospheric pressure is illustrated in Fig. 1. This loss is very low, up to about 450° C., where it increases very rapidly. The infra-red spectrum of an unheated sample shows a hydroxyl vibration band about equally divided into three transmission minima the frequencies of which are located respectively at 3,700 cm.$^{-1}$, 3,663 cm.$^{-1}$ and 3,627 cm.$^{-1}$.

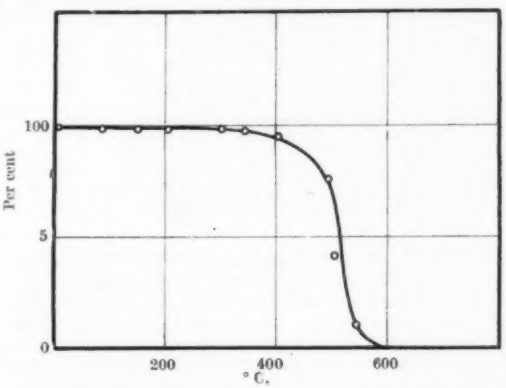

Fig. 1. Relative water content of kaolinite as a function of the temperature under atmospheric pressure

The last one is slightly larger than the other two, the differences being, however, rather small: relative absorbances are 0·91 : 0·92 : 1. When a clay film is heated, the infra-red spectrum undergoes several modifications: the resolution into three components disappears progressively with increasing temperature and, above 400° C., a band only may be observed at about 3,680 cm.$^{-1}$. Beyond this point, relative intensities remain unchanged and, after cooling, the initial shape of the band is restored. Fig. 2 shows the hydroxyl bands observed during a heating and cooling cycle. The process is thus obviously reversible. Fig. 3 gives the changes in frequencies.

One may conclude that, before dehydroxylation starts, kaolinite is modified and brought into a new structural state characterized by the fact that the three initial minima of the hydroxyl vibration band are 'fused' into a single transmission minimum.

As soon as this structural state obtains, dehydroxylation may start, but there is no longer a perfect

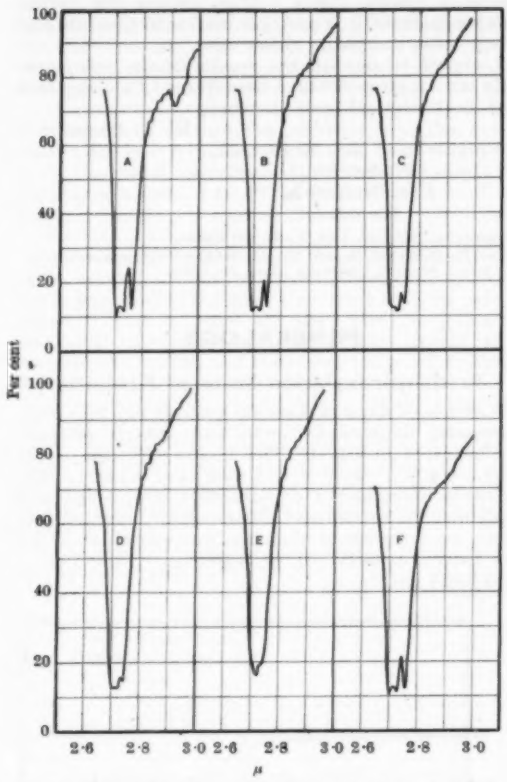

Fig. 2. Hydroxyl bands observed during a heating and cooling cycle before the beginning of dehydroxylation. *A*, 20° C.; *B*, 85° C.; *C*, 210° C.; *D*, 310° C.; *E*, 450° C.; *F*, 20° C.

reversibility of the phenomenon. The absorbance decreases with the water content; the three components of the band reappear when the film is cooled but are shifted about 10–20 cm.$^{-1}$ toward higher frequencies (Fig. 3). In order to represent the progressive mixing of the three components, the height (h) of the barrier between the low- and medium-frequency components, particularly well separated, is given as a function of the temperature as follows:

Temperature	h (in absorbance units)
20° C.	0·295
100° C.	0·175
200° C.	0·095
300° C.	0·040
400° C.	0·02

These values are taken from Fig. 2.

Stübičan[1] has recently studied by infra-red spectroscopy the changes produced in kaolinite by dehydroxylation and has compared the spectra of kaolinite and *meta*kaolinite. He has worked at temperatures which passed the 'predehydroxylation state' here described.

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Stübičan, V., *Min. Mag.*, **32**, 38 (1959).

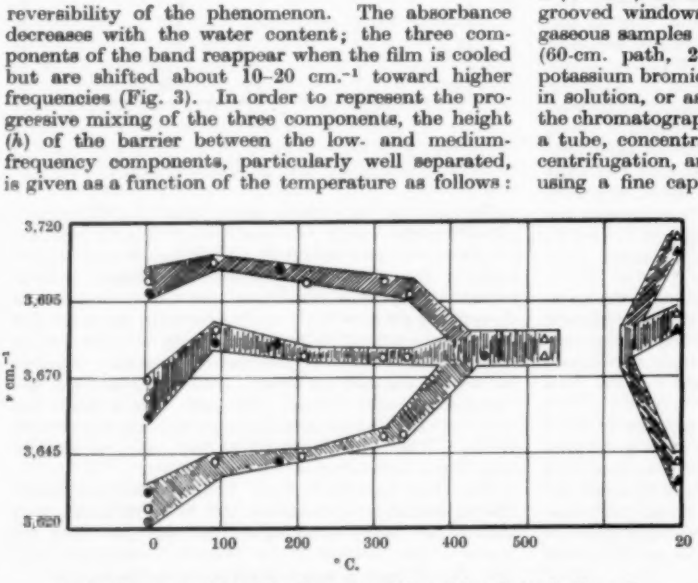

Fig. 3. Frequency shifts of the three transmission minima during heating and cooling cycles. ○, First cycle, 20–310° C.; ●, second cycle, 20–180° C.; ⊙, third cycle, 20–450° C.; △, fourth cycle, 20–520° C.; ▲, fifth cycle, 20–560° C.

CHEMISTRY

Microquantitative Infra-Red Analysis: Application to Gas Chromatographic Fractions

The need to study infra-red absorption spectra of small quantities of sample has led to the development of new micro-sampling devices and techniques. These have been particularly useful in the qualitative identification of gas chromatographic fractions. Their use has now been extended to quantitative analysis of unresolved chromatographic fractions.

Experimental work was done using Beckman *IR*–4 and *IR*–5 spectrophotometers with beam condensers[1] and a *GC*–2 gas chromatograph. Liquid samples were run in a sealed cell (0·1 mm. thick, 2 μl. vol.) or a very thin demountable cell with grooved windows[2] (0·002 mm. thick, 0·02 μl. vol.), gaseous samples in a miniature folded-path gas cell[3] (60-cm. path, 20-ml. vol.), and solid samples in potassium bromide pellets pressed in aluminium foil[4], in solution, or as melted liquids. The effluent from the chromatograph is condensed on the cooled walls of a tube, concentrated at the bottom of the tube by centrifugation, and transferred to the liquid cells by using a fine capillary tube. Vapours are sampled from the space above the liquid or by passing the effluent directly through the gas cell.

Certain peculiarities of microquantitative techniques have led to measuring procedures which might not be the most desirable in the case of macro-samples. In the transmittance-ratio method for two-component mixtures, the transmittance is measured at two appropriate wave-lengths, and the logarithm of the ratio is plotted against the concentration of one of the components, usually providing a straight line of greater slope than single wave-length measurements. In the absorbance-ratio method, the ratio of the absorbances at two wave-lengths is plotted against the

ratio of the concentrations, yielding a straight line provided there is no band overlap. Because the absorbance-ratio method deals with concentration ratios, it does not require close control of cell thickness, solvent concentration, or vapour pressure.

A number of two-component mixtures have been studied using these experimental techniques.

m- and p-Xylene: Spectra of blends of *m*- and *p*-xylene were recorded in the 12–14μ region using the 0·002 mm. cell. Analysis for the *meta* and *para* isomers was based on bands at 13·0 and 12·59μ respectively, using the transmittance-ratio method. A linear calibration plot was obtained. A study of the precision of the method, based on repeated cell fillings with the 1 : 1 mixture, revealed an overall uncertainty in concentration of $\pm$ 0·5 per cent and a standard deviation of $\pm$ 0·15 per cent. A practical example of the use of this analysis occurs in the gas chromatographic determination of a mixture of benzene, toluene, and *o*-, *m*-, and *p*-xylene. Although it is possible to separate *m*- and *p*-xylene chromatographically, it is not always convenient to establish the necessary conditions. In this case benzene, toluene, *o*-xylene, and combined *m*- and *p*-xylene are determined from the chromatogram, the *meta* and *para* isomers are collected and transferred to the micro-cell, and the relative proportions are then determined spectrophotometrically. The concentrations are found to agree satisfactorily with the true concentrations of the blend (Table 1).

Table 1. Typical Combined *GC–IR* Analysis

Component	Known concentration	Determined concentration *GC*	*IR*
Benzene	6·9	7·0	
Toluene	16·0	16·1	
o-Xylene	22·1	21·7	
m-Xylene	36·5	55·2	36·1
p-Xylene	18·5		19·1

To study the effectiveness of the absorbance-ratio method, solutions of the *m*-, *p*-xylene blends in *cyclo*hexane were observed in the 0·1 mm. micro-cell. The plot of concentration ratio versus absorbance ratio yielded a straight line. No attempt was made to control the extent of dilution in solvent beyond ensuring that the xylene peaks were measurable. The effect of variation in dilution was investigated by preparing solutions of the 1 : 1 *meta*-to-*para*-xylene blend in varying amounts of *cyclo*hexane. In the spectra of these solutions the transmittance of the *para*-xylene band varied from 19 to 79 per cent, corresponding to a sevenfold variation in dilution. The measured absorbance ratios were constant to within a small random error amounting to an uncertainty in concentration of $\pm$ 0·5 per cent.

Spectra of about 4 μmoles of each of the *m*-, *p*-xylene blends were observed as vapour sampled from above the liquid phase. Because no quantitative control could be exerted over the combined xylenes trapped in this way, the absorbance-ratio method was used. The resulting curve showed considerable deviation from a straight line because of the strong overlap by the rotational branches of the bands, but was nevertheless a useful calibration curve.

Occasionally, it is not practical to perform an analysis in the usual rock-salt region between 2 and 15μ. Because the beam condenser used in the present study has potassium bromide lenses, it can be used at wave-lengths as long as 25μ. *Meta*- and *para*-xylene have bands in this region at 23·13 and 20·7μ, respectively, which can be used for quantitative measurements. Spectral absorption curves were made using cæsium bromide prisms, and satisfactory transmittance-ratio and absorbance-ratio plots were constructed. The uncertainty in the measurements was somewhat greater than in the measurements at 13·0 and 12·59μ because of increased amplifier gain. The noise can be reduced at the expense of longer scanning time.

m- and p-Cresol: This system is another practical case which occurs because of the difficulty encountered in separating *meta*- and *para*-cresol by gas chromatography. A transmittance-ratio plot, based on the *m*- and *p*-cresol bands at 12·88 and 12·23μ respectively, gave a straight line with the same precision as in the case of the xylenes.

2,6-Xylenol and o-Cresol: This mixture is interesting because 2,6-xylenol is solid at room temperature. Blends were studied in a heated micro-cell at a temperature of about 55° C. Measurements were made at the 8·04 and 8·34μ bands of *o*-cresol and 2,6-xylenol respectively and plotted on a transmittance-ratio basis. Departures from linearity found at high concentrations of each component are very likely due to the influence of hydrogen bonding and could be avoided by use of dilute solutions in a non-polar solvent.

Anthracene and Phenanthrene: Solid mixtures of phenanthrene and anthracene were studied by mixing about 100 μgm. of sample with 10 mgm. of potassium bromide and pressing a 1 mm. × 5 mm. pellet. Measurements were made at 11·31 and 12·22μ for anthracene and phenanthrene, respectively. Difficulty in handling these small samples without loss makes the transmittance-ratio method unsuitable. In the case of phenanthrene–anthracene, it is possible to construct a base-line between the wave-lengths of 10·95 and 12·99μ providing a satisfactory basis for absorbance measurements and a straight line calibration curve.

These experiments demonstrate that satisfactory infra-red quantitative analysis can be performed on 20–100 μgm. of sample in liquid, solution, solid, or gas phase.

Portions of this work were discussed at the Rocky Mountain Spectroscopy Conference (August 12, 1958), the American Chemical Society Southwest Regional Meeting (October 25, 1958), and the Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy (March 6, 1959).

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Mechanism of the Oxidation and Reduction of Metal Ions by Hydrogen Atoms

Recent demonstrations[1–3] that metal hydrides such as CuH^+, AgH^+ and AgH are formed as intermediates in the reduction of metal ions by molecular hydrogen in aqueous solution suggest that similar species may be involved in the oxidation and reduction of metal ions by hydrogen atoms, for example, in the well-known reactions :

$$Fe^{3+} + H + H^+ \rightarrow Fe^{2+} + H_2 \quad (1)$$

and

$$Fe^{3+} + H \rightarrow Fe^{2+} + H^+ \quad (2)$$

These and related reactions between hydrogen atoms and metal ions have now been observed in aqueous solutions in which hydrogen atoms were generated in a variety of ways[4–6] or introduced from the gas phase[7,8]; but their mechanisms are still uncertain and the subject of considerable controversy.

For the oxidation of Fe^{2+} (reaction 1) we propose the following mechanism:

$$Fe^{3+} + H \underset{k_{-3}}{\overset{k_3}{\rightleftharpoons}} FeH^{2+} \quad (3)$$

$$FeH^{2+} + H^+ \xrightarrow[k_4]{} Fe^{3+} + H_2 \quad (4)$$

A detailed kinetic analysis[9] shows this mechanism to be in quantitative accord with the observed[7] dependence of the rate on the Fe^{3+} and H^+ concentrations and yields values of 6×10^4 l. mole^{-1} sec.$^{-1}$ for k_3 and 0·22 for k_{-3}/k_4 at 4°. The mechanism is also consistent with the *p*H independence, over a wide range, of the relative rates of competing reactions of H with Fe^{3+} and other substrates, for example, oxygen[10] or methanol[11]. It is noteworthy that the oxidation of I^- by hydrogen atoms, where analogous hydride formation is unlikely, proceeds by a different mechanism, namely, electron transfer to H_2^+ (ref. 12). While a similar mechanism has been considered[5,6] for the oxidation of Fe^{2+} its contribution apparently is unimportant because of the slowness of formation of H_2^+ ($k_{H+H^+\rightarrow H_2^+} = 10^3$ l. mole^{-1} sec.$^{-1}$) (ref. 12) compared to reaction 3. The absence of an efficient acid-promoted isotope exchange reaction[13] is also in accord with this. The two other mechanisms which have been considered previously for the oxidation of Fe^{3+}, namely, the direct termolecular process (reaction 1) and hydrogen abstraction from the hydration shell of the ferrous ion[14,15], also cannot be reconciled readily with all the experimental facts[9].

The proposed oxidation step (4) is analogous to the back-reaction (−5) which is known[1] to occur in the reduction of Cu^{2+} by H_2:

$$Cu^{2+} + H_2 \rightleftharpoons CuH^+ + H^+ \quad (5)$$

$$CuH^+ + Cu^{2+} \rightarrow 2Cu^+ + H^+ \quad (6)$$

and which leads to the prediction of a mechanism analogous to that described by (3) and (4) for the oxidation of Cu^+ by hydrogen atoms. It seems likely that oxidation of other metal ions will also occur through this type of mechanism.

Reduction of metal ions by hydrogen atoms may proceed by electron transfer (probably through a bridging anion) or by ligand abstraction[16], for example, the reduction of $FeCl^{2+}$ and $FeOH^{2+}$ the rates of which are 10^2–10^3 higher than that of Fe^{3+} aq.[7,10,17]. The very fast reduction of $Fe(CN)_6^{3-}$ ($k = 10^6$–10^7 l. mole^{-1} sec.$^{-1}$) also is almost certainly by electron transfer[16,18]. In other cases, however, hydride intermediates may be involved. This is particularly likely with metal ions such as Ag^+ or Cu^+ the homogeneous reduction of which by electron transfer (that is, to silver or copper atoms) is unfavourable but which form stable hydride complexes. The observed[2] activation energy of 15 kcal. for the reaction:

$$2Ag^+ + H_2 \rightarrow 2AgH^+ \quad (7)$$

implies considerable stability for AgH^+ (with respect to dissociation into either $Ag^+ + H$ or $Ag + H^+$)[18] and suggests both that the reaction:

$$Ag^+ + H \rightarrow AgH^+ \quad (8)$$

will be rapid and that it will occur in preference to electron transfer. It thus seems likely that (8) is the first step in the efficient reduction of Ag^+ by hydrogen atoms followed by dissociation of AgH^+ into H^+ and metallic silver; the latter step is likely to be the slower one and probably involves heterogeneous catalysis. In the reduction of ions such as Fe^{3+} and Cu^{2+} or their complexes there is less reason to believe that initial hydride formation will occur in preference to electron transfer.

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Infra-red Spectra of Ammonia adsorbed on Silica–Alumina Catalysts

In an extension of kinetic studies of the catalytic decompositions of hydrocarbons, infra-red spectra of ammonia chemisorbed upon silica–alumina catalysts have been obtained. The techniques employed were similar to those described previously by Eischens *et al.*[1]. A Perkins–Elmer model 112 *G* infra-red spectrometer utilizing calcium fluoride and lithium fluoride optics was modified by mounting the glowbar source in a position above the infra-red cell housing the catalyst deposit held in a horizontal manner.

Thin films of silica–alumina (87 per cent silicon dioxide) were prepared by sedimentation methods: approximately 1 gm. of the 'fluid' catalyst was suspended in 10 ml. of water by vigorously shaking the mixture in a tube and withdrawing the finer particles by means of a small pipette. Sufficient quantities of the suspension of fine particles were placed in a medicine-type throat atomizer and then sprayed on to a calcium fluoride plate oriented vertically over a small hot-plate, namely, with the flat surface perpendicular to the plane of the laboratory desk top. This technique was important

in obtaining uniform catalyst films and preventing puddling. Each application of the aqueous suspension to the calcium fluoride plate was allowed to approach dryness before additional spraying commenced. The density of the catalyst deposits was of the order of 2–3 mgm./cm.[2]. Final pretreatment of the silica–alumina consisted of dehydration at 450–500° C. for 16 hr.

Infra-red spectra of ammonia tenaciously adsorbed upon a catalyst having a surface area of 600 m.[2]/gm. were observed at room temperature. These spectra exhibit considerable differences from similar investigations reported by Mapes and Eischens[2]. In the current study a series of infra-red absorption bands were resolved in the vicinity of 3,300–3,170 cm.$^{-1}$ attributable to ammonia adsorbed on Lewis acid sites. A second set of absorption frequencies were noted between 3,025 and 2,900 cm.$^{-1}$ ascribable to the reaction products of ammonia and Brønsted sites. From band-widths and band-intensities it was estimated that the concentrations of Lewis to Brønsted sites are in the ratio 3/2, respectively, near room temperature and the ratio increases with rising temperature. A minimum of three discrete energy-levels of Lewis acids and four definite energy-levels of Brønsted sites was detectable. The multitude of infra-red bands exhibited in the stretching region of the spectrum diminished in intensity with decreasing surface coverage in such a manner as to provide further evidence for adsorption sites of differing energies. That is, the ratios of band-intensities changed perceptibly as the ammonia was removed by pumping and elevation of temperature.

The kinetic results of Franklin and Nicholson[3] showed a compensation effect whereby high values of energy of activation corresponded to high values of the frequency factor, and vice versa. The kinetic results could be correlated on the assumption of a logarithmic relationship between the frequency factor and the energy of activation. This observation is suggestive of a distribution of catalytic centres according to their acid strength. The spectroscopic results cited above provide independent confirmation of the distribution of adsorption site energies on the silica–alumina catalyst. The optical spectra suggest that even though the energy distribution may be somewhat continuous in nature, a preponderance of the chemisorption of ammonia occurs upon a small number of spots in an energetic sense.

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Addition Compounds between Copper Complexes and Organic Bases

In a recent communication[1], Graddon interpreted the formation of an addition compound between copper complexes such as cupric acetylacetonate and pyridine or other bases as due to formation of a 5 co-ordination complex of the copper atom. This is not the only possible interpretation, nor the most probable one.

The investigations of Lowry *et al.*[2] showed that such bases, together with *p*-cresol, alcohol and probably acetone, can act as catalysts for the mutarotation of beryllium benzoyl camphor and aluminium benzoyl camphor dissolved in carbon tetrachloride or chloroform. In these compounds the metal atoms are showing maximum co-ordination, and the only likely interaction between the catalyst and substrate is by the former replacing one of the points of attachment of the chelate group to the metal atom, the mutarotation becoming possible when the second chelate group (in the beryllium compound) is also detached at one end by thermal energy, amounting to about 20,000 cal./mole. This is supported by the increase in optical rotatory power shown by solutions containing *p*-cresol. It would therefore seem likely that the bases used by Graddon are similarly able to detach part of a chelate group. It is not clear, however, why only one molecule of the base has been found to be attached to a metal atom.

It may further be noted that Graddon used chloroform as solvent in some of his experiments. Lowry *et al.* also showed that beryllium benzoyl camphor forms crystals from chloroform solution containing two molecules of chloroform to each metal atom, and that when these are dissolved in carbon tetrachloride the optical rotatory power differs from those of either the unsolvated material or of the equilibrium mixture: they postulated that it contained equal proportions of the two optically active isomers. It may be interpreted as formed by the replacement of one end of each chelate group by a chloroform molecule, probably attached through a chlorine atom to the metal atom, and also forming a hydrogen bond with the oxygen atom of the detached group. The possibility of similar effects in solutions of copper complexes in chloroform should not be overlooked.

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Reaction of *p*-*n*-Decyloxybenzenediazonium Fluoborate with Sodium Iodide in Benzene

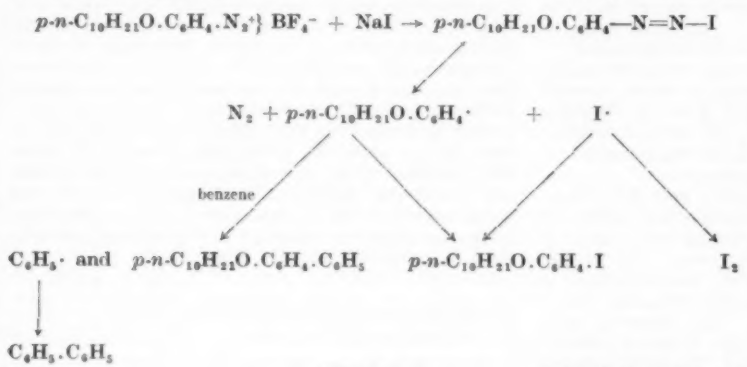
In an earlier communication[1] it was shown that several diazonium salts belonging to the series, $RO.C_6H_4.N_2^+\}X^-$, reacted with β-naphthol in benzene containing an equivalent amount of pyridine to form normal azo-compounds. With Grignard reagents, however, *p*-*n*-decyloxybenzenediazonium salts gave not only the expected azo compounds but also *p*-*n*-decyloxydiphenyl and *n*-decyloxybenzene which must have been formed from *n*-decyloxyphenyl radicals produced at an earlier stage. A further instance of the occurrence of radical reactions in the chemistry of diazonium salts has now been found in the reaction of *p*-*n*-decyloxybenzenediazonium fluoborate in benzene with sodium iodide dissolved in a small volume of dry acetone. Addition of the sodium iodide solution at the room temperature produced a yellow colour followed by the evolution of nitrogen and formation of *p*-iodo-*n*-decyloxybenzene and, in addition, free iodine, an equivalent amount of *p*-*n*-decyloxydiphenyl, and a trace of diphenyl. The *p*-*n*-decyloxydiphenyl must have arisen by pro-

duction of *n*-decyloxyphenyl radicals and their subsequent reaction with the medium. The formation of diphenyl requires the intermediate production of phenyl radicals, presumably by reaction of *n*-decyloxyphenyl radicals with benzene. When the volume of benzene was increased the yield of *p*-iodo-*n*-decyloxybenzene was reduced, but both iodine and *p*-*n*-decyloxydiphenyl were found in increased, and equivalent, amount.

Using *p*-*n*-decyloxybenzenediazonium fluoborate (7·050 gm.) in dry benzene and sodium iodide (3·832 gm.) in dry acetone (25 ml.) the yields obtained were :

Volume of benzene (ml.)	Mol. of *p*-iodo-*n*-decyloxybenzene (per cent)	Mol. of *p*-*n*-decyloxydiphenyl (per cent)	Mol. of iodine (per cent)	Total diazonium salt accounted for (per cent)	Total iodine accounted for (per cent)
200	60	14	15	74	75
600	46	26	26	72	72

The following sequence of reactions would explain the results obtained :



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Radiation Labelling with Carbon-14 of Aliphatic Hydrocarbons

Radiation labelling techniques have been successfully developed to introduce tritium atoms in a number of organic molecules[1]. Such a method may also be applied to preparation of carbon-14-labelled compounds, taking advantage of radiation-induced reaction between an organic substance and that containing the radioisotope. Preliminary reports[2] describe the identification of a number of radioactive carboxylic acids in mixtures containing hydrocarbons (or heterocyclic compounds) and carbon-14 dioxide irradiated with X- or beta-rays. Substantially better results, as regards the amount of radioactivity incorporated into the reaction products, have been now attained in the radiation labelling of aliphatic hydrocarbons promoted by high doses of gamma-rays (from spent elements of nuclear fuel) in gaseous systems containing labelled methane as the source of radiocarbon, a saturated hydrocarbon of low molecular weight and an inert gas. Typical experimental conditions were as follows : a mixture of 0·75 m.mole of radioactive methane (specific activity 0·5 mc./m.mole), 0·75 m.mole of propane and 3·0 m.moles of xenon was irradiated in a sealed 'Pyrex' ampoule (125 c.c. approximate capacity). Addition of xenon increased considerably the energy transfer from ionizing radiation to the hydrocarbon mixture, as shown by preliminary runs. The irradiation dose was estimated to be $0{\cdot}99 \times 10^8$ rads.

The contents of the vessel were then frozen in liquid nitrogen, the methane pumped away and the residue thoroughly outgassed by the conventional melting-freezing technique. Gas chromatographic methods were employed to separate the radioactive hydrocarbons in the irradiated sample, a mixture of ethylene, propane, butane and *iso*butane, pentane and *iso*pentane, and hexane carriers having been previously added. The gas chromatographic apparatus employed for the analysis was equipped with a conventional thermoconductivity detector, in series with a 100-ml. ionization chamber, connected to a vibrating reed electrometer[3]. Thermoconductivity cell and electrometer responses were registered on synchronized recorders for simultaneous chemical and radiochemical analysis. Satisfactory efficiency in chromatographic separation was attained using two different columns for the analysis of C_2–C_5 and C_6 hydrocarbons : columns containing as stationary phase acetonylacetone on 'Celite *C* 22' and dinonylphthalate on 'Celite *C* 22', respectively 6 m. and 4 m. long, were chosen for analysis of lighter hydrocarbons, with nitrogen as carrier gas, the temperature being 15° C. (Fig. 1). A column of dinonylphthalate on 'Celite *C* 22', at 55° C., was adopted for C_6 compounds.

The radioactivity of each compound was evaluated by integrating the area of the corresponding radiochemical peak. Total radioactivity was determined by two independent methods : (i) calculating the activity corresponding to the sum of the radiochemical peaks ; and (ii) counting known amounts

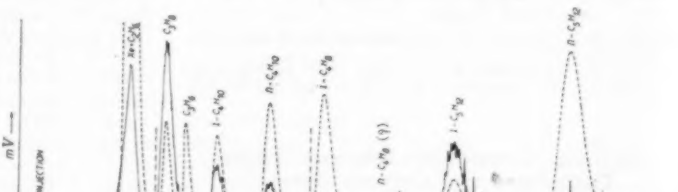

Fig. 1. Radiometric analysis of labelled hydrocarbons C_2–C_5. The full line refers to electrometer response, dotted line to thermoconductivity cell output. Vertical dotted lines correspond to full-scale changes in ionization current

Table 1*

Compound	Activity (μc.)†
Ethane‡	14·80
Propane	2·40
Propylene	—
i-Butane	0·96
n-Butane	0·92
i-Butene	—
Unknown§	0·11
i-Pentane	0·51
n-Pentane	0·15
i-Hexane	1·14
n-Hexane	0·49
Total	21·48 μc.

* The activity of methane in irradiated mixture was 0·370 mc.
† Radioactivity data were obtained as the mean value of several measurements, the standard deviations being less than 5 per cent.
‡ Radioactive ethylene may be contained in the ethane peak, due to the poor separation in the presence of large excess of xenon.
§ Probably unsaturated linear butenes.

of the radioactive mixture, introduced into a 250-c.c. ionization chamber of the Borkowsky modified type.

The results obtained are summarized in Table 1. It can be seen that a comparatively high percentage of methane radioactivity is contained in the reaction products. Further, the specific activity of the labelled hydrocarbons—except propane—is very high before dilution with carriers. It should also be pointed out, in evaluating the practical interest of the results summarized in Table 1, that the activity of labelled compounds could be substantially increased—in about the ratio 20 : 1—simply by irradiating a mixture containing methane of the maximum available specific activity. Finally, it is worth mentioning that, despite the high dose of gamma-rays absorbed by the gaseous system, only a small amount of the radioactivity was found in unsaturated hydrocarbons.

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BIOCHEMISTRY

Electrophoretic Components of the Proteins in Honeybee Larval Food

THE proteins of the larval food of the honeybee, *Apis mellifera* L., have been resolved into a number of components by zone electrophoresis[1–3]. The total protein content of larval food (royal jelly) given to female larvæ being reared in queen cells remains fairly constant throughout the feeding period. However, a marked drop in total protein occurs in the food given to worker larvæ midway in the feeding period[4]. It has been observed that larvæ from worker cells can develop into fully mature adult queens if transferred to queen cells (receiving queen larval food or royal jelly) during the first three days of larval life[5]. The purpose of this communication is to note the relation of electrophoretic pattern of larval food proteins to the age and caste of the larvæ receiving the food.

Larval food was gathered from brood cells containing old larvæ (4–6 days of larval life) and young larvæ (less than 3 days) of each caste. Care was taken in obtaining the food samples to avoid contamination from materials clinging to the sides of the cells. The samples were kept at −40° C. until a pool of each caste and age-group was collected. They were obtained during the height of brood rearing from the colonies maintained in the University apiary.

The pools were thawed, stirred, and 1-gm. samples (fresh weight) withdrawn. Each sample was extracted by stirring in 10 ml. of water followed by centrifuging. This was repeated with successive amounts of water until no more protein was found in the supernatant as judged by the biuret test. These were the water extracts. The residue from each sample was then further extracted with alkali (0·5 per cent sodium carbonate) to the same end-point. These were the alkali-soluble extracts. The extracts from each sample and treatment, respectively, were pooled and dialysed against water (changed twice daily) until the dialysate was negative to ninhydrin (about 4 days). The extracts were then pervaporated to 2 ml. volume.

20 μl. of each sample were spotted on Munktell 20*S* paper at a line 14 cm. from the cathode buffer reservoir of an *LKB* model 3276 electrophoresis apparatus. The reservoirs were filled with *M*/10 barbital buffer, *p*H 7·4. Current (4·3 V./cm.) was applied for 18 hr. The sheets were removed, dried with a hair-dryer, and stained with bromphenol-blue[6].

The distribution of water-extracted stained proteins is shown in Fig. 1. There is no qualitative difference apparent between the proteins in the food of young larvæ of queen, worker, and drone castes. Spots 1 and 3, however, are not found in the old worker and drone larval food. A single zone with a migration equivalent to that of spot 3 was present in alkaline extracts of all food samples examined. Thus it is apparent that the qualitative change of the protein constituents of worker and drone larval food is restricted to the water-soluble fractions.

A bluish fluorescent zone not associated with any of the proteins was visible on unstained electro-

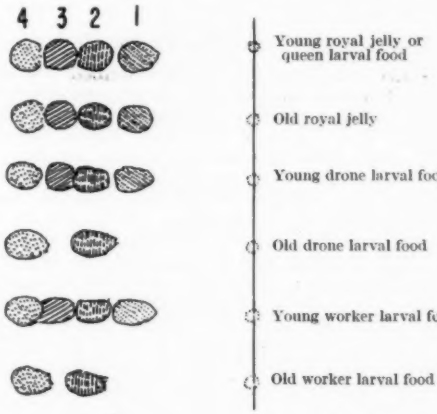

Fig. 1. Electrophoretic patterns (drawn to scale) of proteins from food of honeybee larvæ of different age and caste

phorograms of food of younger worker and drone larvæ and of food of both ages of queen larvæ. The fluorescence may indicate the presence of biopterin[7], which has been associated with queen larval food.

The source of brood-food proteins was sought in adult worker bees: 16 pairs of each of the mandibular, hypopharyngeal and thoracic glands were dissected from (*a*) 6-day post-emergence nurse bees; (*b*) newly emerged bees. The glands were macerated in 0·5 ml. phosphate (*M*/10, *p*H 6·0) and electrophorograms prepared as above. The electrophoretic pattern obtained from the hypopharyngeal glands of the 6-day post-emergence adults was similar to that of queen larval food, whereas other glands and glands of newly emerged bees contained a single, immobile spot. The source of young brood-food protein appears to reside in the fully active pharyngeal gland.

Thus the divergence of maturation of the fully fertile queen from that of the infertile worker coincides chronologically with the qualitative change in protein composition of brood-food given to the larvæ of the latter caste. A more concerted study of the changes occurring in the brood-food at this time could help explain the mechanism of this divergence. For example, Ammon and Zock[2] localized cholinesterase activity in their alpha fraction and acid phosphatase in their gamma fraction, corresponding to our spots 2 and 4. It is possible that loss of other biological or nutritional activity is associated with loss, in the older worker larval food, of spots 1 and 3. Such a loss could be related in some way to the subsequent sexually incomplete development of the worker caste.

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Desalting of Urine by Electrodialysis

The electrodialyser previously described[1] has been used for desalting samples of urine prior to chromatography. This apparatus (obtainable from Shandon Scientific Co., Ltd., 6 Cromwell Place, London, S.W.7) was used successfully in the desalting of tissue extracts; but Smith[2], using a modified version of the desalter, reported considerable losses of amino-acids during desalting of urine. It was considered desirable to repeat the experiments in the original apparatus by plotting the 'desalting curve' and submitting samples desalted for varying lengths of time to two-dimensional chromatography.

The urine was part of a 24-hr. sample from a patient at the Royal Alexandra Hospital for Children, Sydney. 10-ml. portions were diluted with 10 ml. of water and placed in the centre compartment of the cell and tap-water was run through the electrode compartments. The current was switched on and the voltages adjusted periodically to maintain the current flowing at 0·200 amp. for the greater part of the run. After 43 min. the resistance of the cell had begun to rise steeply, and the removal of ions was substantially complete (run *B*).

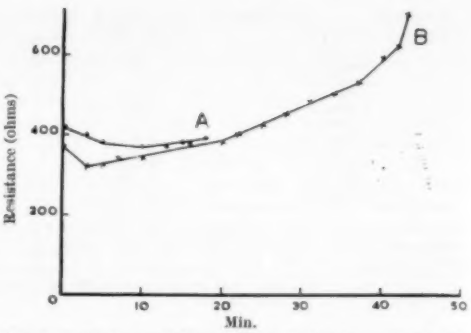

Fig. 1. Ordinates: resistance of the cell. Abscissæ: time in min. Runs *A* and *B* are indicated

The plot of resistance against time is shown in Fig. 1. Initially, the resistance of the cell falls as salt begins to pass through the membranes; after 20 min. the greater part of the inorganic salts has been removed, and more of the current is being carried by organic ions, as shown by the increase in gradient; finally, the curve rises steeply as the solution becomes exhausted of ions.

Runs *A* (and *C*) were carried out in the same way but were terminated after 18 min. and 10 min. respectively.

The solutions from runs *A*, *B* and *C*, and the original urine were brought to dryness under reduced

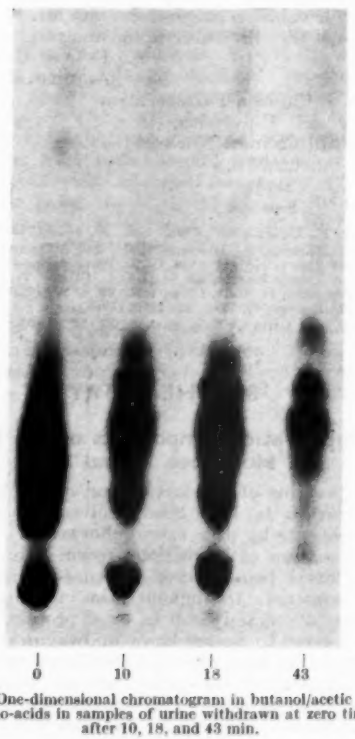

Fig. 2. One-dimensional chromatogram in butanol/acetic acid of the amino-acids in samples of urine withdrawn at zero time and after 10, 18, and 43 min.

pressure and diluted to 2 ml. with 10 per cent v/v *iso*propanol. Equal amounts of each sample were chromatographed in butanol/acetic acid[2] (ascending) followed by phenol/ethanol[2] on Whatman No. 1 paper and developed with ninhydrin. Two-dimensional chromatograms of the urine desalted for 10 min. gave good discrete spots compared with the original urine. A one-dimensional chromatogram of samples withdrawn at various times during the run is shown in Fig. 2.

It is evident from the results that, provided a 'desalting curve' for the urine is plotted, it is possible to stop the run at a time when most of the salt has been removed but little or no amino-acid has been lost. It is also suggested that a procedure of 'total desalting' might be useful in clinical laboratories to measure the total amount of electrolyte in urine, since this is directly proportional to the average current × time.

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Biosynthesis of Flavonoids

Several workers have shown that lignin and the '*B* ring' of flavonoids are formed *in vivo* from shikimic acid and certain C_6C_3 compounds. The latter compounds are frequently encountered in plant tissues[1]. The '*A* ring' of flavonoids appears to arise from acetate units[2]. However, the occurrence of the free '*A* ring' or simple derivatives of it have rarely been reported. We have found that on acid treatment kinos yield phloroglucinol, but bark and wood polyphenols do not.

Concentrated hydrochloric acid was added to an aqueous ethanolic (1 : 1) solution (5 ml.) of the kino (0·2 gm.), until the strength was 3 *N*. The open test-tube containing the solution was heated in boiling water for 1 hr., and the reaction products examined by two-way chromatography in butanol/acetic acid/water (6 : 1 : 2) and 6 per cent acetic acid. All the kinos examined produced phloroglucinol, which was identified by co-chromatography, its appearance under ultra-violet light while fuming with ammonia (s.g. 0·88) and its colour reaction to diazotized *p*-nitroaniline[3] and vanillin-hydrochloric acid[4].

Phloroglucinol was isolated from *Pterocarpus marsupium* kino (5 gm.) by treating in a similar manner, adding sodium carbonate to the filtered reaction products until the acid strength was about 1 *N*. The resulting liquor was placed on a polyamide column[5] and, after washing with water, the column was developed with ethanol/water (3 : 7) and the phloroglucinol recovered from the appropriate fractions in 0·5 per cent yield. The crystals did not depress the melting point of authentic phloroglucinol and possessed the same infra-red spectrum.

When the kinos were treated with butanol – hydrochloric acid, the anthocyanidins produced by the leucoanthocyanins present were identified chromatographically using Forestal[6] and formic acid – hydrochloric acid – water[7] solvents, and they all contained a phloroglucinol '*A* ring'. In addition, *Eucalyptus* and *Angophora* kinos gave gallic acid, and some kinos gave methyl gallate and protocatechuic acid which were identified by co-chromatography on 2-way chromatograms.

The kinos examined, and the principal anthocyanidins produced with acid, were as follows: *Eucalyptus calophylla* (pelargonidin and cyanidin), *E. camaldulensis* (cyanidin), *E. consideniana* (delphinidin), *E. corymbosa* (cyanidin), *E. elaeophora* (delphinidin), *E. gigantea* (delphinidin), *E. macrorrhyncha* (delphinidin), *E. obliqua* (delphinidin), *E. polycarpa* (cyanidin), *E. radiata* (delphinidin), *E. regnans* (delphinidin), *E. sideroxylon* (pelargonidin, cyanidin, delphinidin), *E. sieberiana* (delphinidin), *Angophora intermedia* (cyanidin), *Pterocarpus marsupium* (cyanidin), *Butea frondosa* (cyanidin).

The material yielding phloroglucinol with acid treatment was insoluble in ether, and formed unresolved streaks on the solvent axes. When solutions of *E. elaeophora* and *P. marsupium* kinos in aqueous ethanol (1 : 1) were made 2 *N* with sodium hydroxide, kept at room temperature for 2–4 hr., then acidified, phloroglucinol was not detected, so that esters of it are absent. Sugars could not be detected in the acid reaction products.

In contrast, extracts of the wood and phloem tissues of several of the above eucalypts which had formed kinos did not yield phloroglucinol on acid treatment. Extracts from the wood of *E. wandoo*, and the barks of *E. astringens* and *Rhizophora mucronata* which are rich in leucoanthocyanins containing a phloroglucinol '*A* ring' also failed to yield phloroglucinol. Thus, kinos contain phenolic components which are absent in the phloem and woody tissues, and consequently kinos appear to be formed *in situ* from other materials. Further evidence[8] indicates that the polyphenols in kinos and in the tissues of trees are formed from carbohydrates which have been translocated or stored as starch.

I am indebted to Miss E. Gloss for experimental assistance.

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PHYSIOLOGY

Œstrogen–Insulin Interaction on the Uterus of the Rat

The physiological activity of a specific hormone may be greatly modified by the presence or absence of other hormones, as evidenced, for example, by the Houssay effect[1]; the inhibitory action of adrenal cortical hormones on the response of the rat uterus to œstrogens[2]; the interaction of the various œstrogens on uterine growth[3]; the synergistic effect of growth hormone and thyroxine on body-growth in hypophysectomized animals[4], etc. Of more immediate

relevance to the subject to be treated here is the finding that the response of the mouse vagina to œstrogen is heightened by local application of insulin[5]; analogies between the effects of œstrogen and those of insulin on the mitotic activity of mouse ear epidermis have been pointed out by Bullough[6]. Other similarities between the generalized action of insulin and the specific effects of œstrogens on their target organs include an increased potassium uptake by the responding tissue[7–9], and a heightening of glycogenesis and lipogenesis[10–16]. The foregoing observations, together with the fact that except in a few specific preparations œstrogens are ineffective *in vitro*[18], and in large doses produce a transient diabetes[16], suggest a possible interaction between insulin and œstrogen.

The investigations described here were designed to establish whether diabetes and insulin-induced hypoglycæmia would affect the response to œstrogen based on the 6-hr. Astwood assay[17]. This would presumably indicate whether insulin plays a part in the action of œstrogen, and whether the blood glucose is also involved.

Twenty-one- to twenty-two-day old albino rats weighing 40–50 gm. were employed in this study. Diabetes was induced by partial pancreatectomy followed by the subcutaneous injection of 1 c.c. of a 40 per cent glucose solution; 1 hr. after the administration of glucose the animal received 0·5 μgm. of œstrone in 0·1 c.c. of sesame oil subcutaneously; autopsy was performed 6 hr. after the injection. Œstrogen-treated and un-treated non-operated, sham-operated, operated but glucose-uninjected controls were also provided. The extent of the diabetes was determined by the use of the Lilly diabetic test tape; all partially depancreatized glucose-treated animals exhibited at least a ++++ response, that is, a urine sugar content of at least 2 per cent, at autopsy.

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4 Received 0·5 μgm. œstrone 12 hr. after injection of 2 units of 'Lente' insulin	83·1 ± 0·5	8
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* Mean ± standard error of the mean

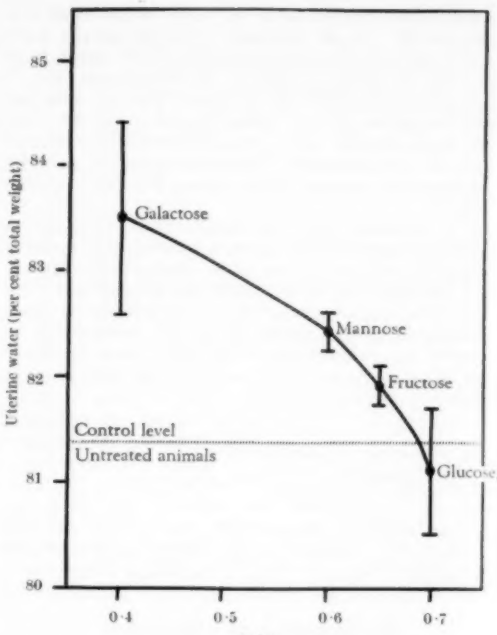

Fig. 1. Relation between S_m/S_s and uterine water uptake in depancreatized diabetic immature rats

None of the other animals in this set of experiments exhibited any evidence of glucosuria.

Hypoglycæmia was induced by injection of insulin 12–14 hr. before the administration of œstrone. Uterine wet weights were determined immediately upon removal of the organ; the tissue was then placed in a pre-weighed aluminium pan and dried at 90° C. for 72 hr.

Additional pancreatectomized groups were provided in which glucose was replaced by fructose, mannose, or galactose; some of the pancreatectomized sugar-treated animals exhibited mild glucosuria.

From the results presented in Table 1 it is evident that the response to œstrogen was dependent upon the physiological integrity of the test animal; the absence as well as the excess of insulin inhibited the action of œstrone. It is difficult to determine whether the inhibition due to lack of insulin was a direct one; diabetic animals exhibit a marked polyuria, and recent studies have indicated that the 6-hr. response to œstrogen is diminished in 'Diamox'-treated animals, which lose a great deal of water[18]. Adrenal involvement in the reduction of the œstrogen response in glucose-treated partially depancreatized animals appears minimal in view of the results obtained with sham-operated glucose-treated controls. It is noteworthy that not all the sugars tested are equally effective in blocking the action of œstrone under identical experimental conditions; Fig. 1 relates the extent of the inhibition to the degree to which normal rat muscle takes up sugar under a given dose of insulin; this parameter was derived from the work of Park *et al.*, who express it as the ratio of the free sugar in the tissue to the sugar concentration in the blood serum (S_m/S_s)[19]. The inverse relation between

the extent of œstrogen stimulation and the 'insulin demand' of muscle is highly suggestive.

The fact that insulin-pretreated animals do not respond to œstrogen does not conclusively point to a direct involvement of the blood glucose in the response phenomenon, as the inhibition might be ascribed to increased adrenal secretion in response to the stress of hypoglycæmia. This hypothesis is rather difficult to check in view of the extreme sensitivity of adrenalectomized hyperinsulinized animals.

In view of the results obtained it seems worth while to speculate on the inhibition of œstrogen-induced water uptake observed in the uteri of eviscerated animals. Some reports have explained this phenomenon as resulting from the absence of liver tissue[20]. The results reported here would point to the absence of pancreatic tissue as a prime factor in this inhibition.

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Intracellular Potentials in Rat Atria during and after Vagal Stimulation or Acetylcholine Administration

Recently, Vaughan Williams[1] observed that the shortening of the duration of the intracellularly recorded action potential in rabbit atria following vagal stimulation or acetylcholine administration is not always associated with diminished atrial contractions. In fact the association between the two phenomena as observed by Burgen and Terroux[2] might be coincidental. The question arose whether the slowing-up of the atrium which will result from vagal stimulation or acetylcholine administration is always connected with a shortening of the duration of the atrial action potential. The right atrium of adult Wistar rats was impaled with glass microelectrodes filled with 3 *M* potassium chloride, their tip diameter being $< 0{\cdot}5\mu$ and their resistance 20–35 MΩ. After retrograde insertion of a plastic cannula in the thoracic aorta, the heart and both vagi were perfused *in situ* with normal Tyrode solution. The vagi were stimulated with rectangular current pulses of varying intensity. The pulses had a frequency of 10 c./sec. and a duration of 0·5 m.sec. In a few experiments we succeeded in recording intracellular atrium potentials from artificially ventilated animals that had an intact circulation. The results obtained with perfused rats and with rats with an intact circulation did not differ.

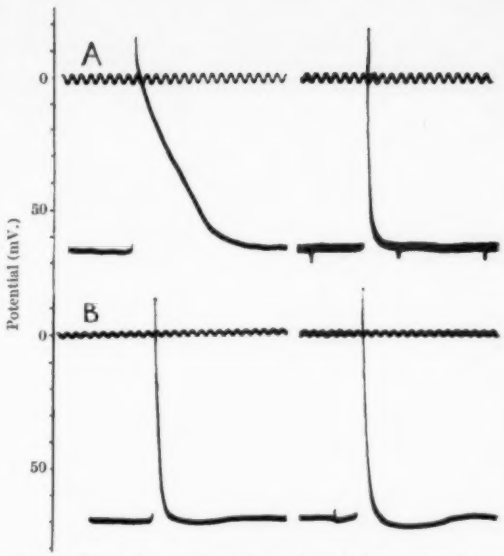

Fig. 1. Effect of vagal stimulation and acetylcholine administration on atrial potentials. *A*, left, normal atrial potential; right, atrial potential during vagal stimulation. *B*, left, atrial potential shortly before cardiac arrest as caused by acetylcholine administration; right, potential of driven atrium during acetylcholine administration. Time marks, sine wave of 100 c./s. Stimulus artefacts are visible in right-hand records

During vagal stimulation or during the administration of acetylcholine to the perfusion fluid or to the venous blood the duration of the atrial potential decreased from 100 to about 20 m.sec. The degree of slowing-up of the atrium and the shortening of the atrial action potential were found to be dependent equally upon the intensity of the vagal stimulation and the concentration of acetylcholine in the perfusion fluid or in the blood. Immediately after the arrest of vagal stimulation the heart frequency rose to its original value within 1 sec. In most experiments post-vagal acceleration of heart frequency was observed.

The shortening of the duration of the action potential, however, did not disappear as quickly as the atrial slowing and reached its original value only after 7–15 sec. after the arrest of vagal stimulation. The same observation was made when perfusion with Tyrode solution containing acetylcholine was suddenly replaced by perfusion with normal Tyrode.

In a further series of experiments cardiac arrest was established by perfusing the heart with a Tyrode solution containing 20γ acetylcholine/ml. As an atrium under these conditions will still respond with a contraction to an electrical stimulus[1], the atria were electrically driven up to their original frequency. Despite this frequency of contraction, the duration of the atrial potential remained considerably shortened

relevance to the subject to be treated here is the finding that the response of the mouse vagina to œstrogen is heightened by local application of insulin[5]; analogies between the effects of œstrogen and those of insulin on the mitotic activity of mouse ear epidermis have been pointed out by Bullough[6]. Other similarities between the generalized action of insulin and the specific effects of œstrogens on their target organs include an increased potassium uptake by the responding tissue[7–9], and a heightening of glycogenesis and lipogenesis[10–16]. The foregoing observations, together with the fact that except in a few specific preparations œstrogens are ineffective *in vitro*[15], and in large doses produce a transient diabetes[16], suggest a possible interaction between insulin and œstrogen.

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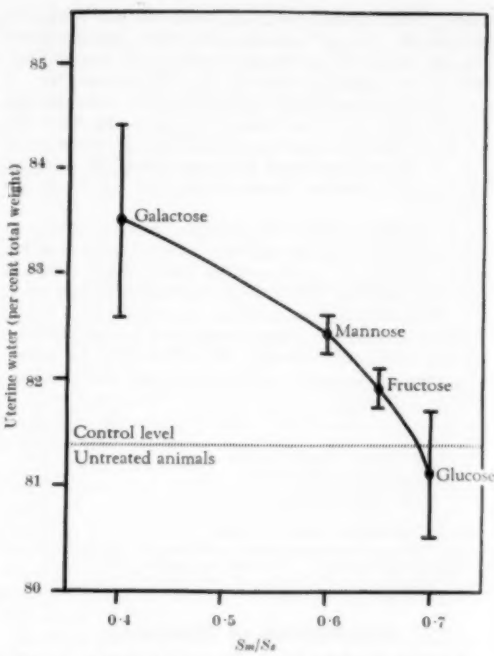

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the extent of œstrogen stimulation and the 'insulin demand' of muscle is highly suggestive.

The fact that insulin-pretreated animals do not respond to œstrogen does not conclusively point to a direct involvement of the blood glucose in the response phenomenon, as the inhibition might be ascribed to increased adrenal secretion in response to the stress of hypoglycæmia. This hypothesis is rather difficult to check in view of the extreme sensitivity of adrenalectomized hyperinsulinized animals.

In view of the results obtained it seems worth while to speculate on the inhibition of œstrogen-induced water uptake observed in the uteri of eviscerated animals. Some reports have explained this phenomenon as resulting from the absence of liver tissue[20]. The results reported here would point to the absence of pancreatic tissue as a prime factor in this inhibition.

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Intracellular Potentials in Rat Atria during and after Vagal Stimulation or Acetylcholine Administration

Recently, Vaughan Williams[1] observed that the shortening of the duration of the intracellularly recorded action potential in rabbit atria following vagal stimulation or acetylcholine administration is not always associated with diminished atrial contractions. In fact the association between the two phenomena as observed by Burgen and Terroux[2] might be coincidental. The question arose whether the slowing-up of the atrium which will result from vagal stimulation or acetylcholine administration is always connected with a shortening of the duration of the atrial action potential. The right atrium of adult Wistar rats was impaled with glass microelectrodes filled with 3 *M* potassium chloride, their tip diameter being $< 0{\cdot}5\mu$ and their resistance 20–35 MΩ. After retrograde insertion of a plastic cannula in the thoracic aorta, the heart and both vagi were perfused *in situ* with normal Tyrode solution. The vagi were stimulated with rectangular current pulses of varying intensity. The pulses had a frequency of 10 c./sec. and a duration of 0·5 m.sec. In a few experiments we succeeded in recording intracellular atrium potentials from artificially ventilated animals that had an intact circulation. The results obtained with perfused rats and with rats with an intact circulation did not differ.

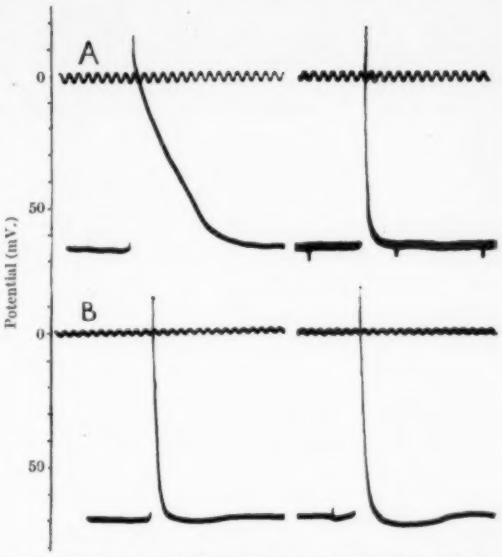

Fig. 1. Effect of vagal stimulation and acetylcholine administration on atrial potentials. *A*, left, normal atrial potential; right, atrial potential during vagal stimulation. *B*, left, atrial potential shortly before cardiac arrest as caused by acetylcholine administration; right, potential of driven atrium during acetylcholine administration. Time marks, sine wave of 100 c./s. Stimulus artefacts are visible in right-hand records

During vagal stimulation or during the administration of acetylcholine to the perfusion fluid or to the venous blood the duration of the atrial potential decreased from 100 to about 20 m.sec. The degree of slowing-up of the atrium and the shortening of the atrial action potential were found to be dependent equally upon the intensity of the vagal stimulation and the concentration of acetylcholine in the perfusion fluid or in the blood. Immediately after the arrest of vagal stimulation the heart frequency rose to its original value within 1 sec. In most experiments post-vagal acceleration of heart frequency was observed.

The shortening of the duration of the action potential, however, did not disappear as quickly as the atrial slowing and reached its original value only after 7–15 sec. after the arrest of vagal stimulation. The same observation was made when perfusion with Tyrode solution containing acetylcholine was suddenly replaced by perfusion with normal Tyrode.

In a further series of experiments cardiac arrest was established by perfusing the heart with a Tyrode solution containing 20γ acetylcholine/ml. As an atrium under these conditions will still respond with a contraction to an electrical stimulus[1], the atria were electrically driven up to their original frequency. Despite this frequency of contraction, the duration of the atrial potential remained considerably shortened

so long as the acetylcholine administration was continued. On discontinuing the acetylcholine perfusion the duration of the atrial potential gradually rose to its original value.

Consequently we have come to the conclusion that shortening of the duration of the auricular potential during vagal stimulation does not depend upon the rate of the atrial contractions.

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Effect of Methylpentynol on Acetylcholine in the Rat's Brain

Recent observations that methylpentynol, a sedative-hypnotic agent, interferes with transmission in certain cholinergic synapses[1], have led to the demonstration by Marley and Paton that this action is due in part to a reduction in the output of acetylcholine, at least from the superior cervical ganglion of the cat[2]. In the course of work in this and other laboratories on the influence of a number of appropriate neuro-pharmacological agents on the acetylcholine content of the rat's brain, it became apparent that the administration of depressants of the central nervous system in general is followed by a rise in brain acetylcholine (unpublished work and ref. 3). It seemed essential, therefore, for us to include methylpentynol in our survey, because this central-depressant might, in the light of the findings of Marley and Paton, depress the output of acetylcholine by the brain, possibly leading to a depression of the total level of acetylcholine. On the other hand, if release of acetylcholine alone, and not its synthesis, were interfered with, one might expect an accumulation and an increase in the amount of acetylcholine in the brain.

Adult male rats (150–250 gm.) were given intraperitoneal injections of methylpentynol in doses varying from 200 to 500 mgm./kgm. At a time shortly after loss of the righting reflex, when the animals were believed to be at the point of greatest central depression, the rats were decapitated, their whole brains (without olfactory lobes and pituitaries) quickly removed and extracted for acetylcholine by the method of Smallman and Fisher[4]. The content of acetylcholine in these extracts was determined by bioassay on the frog's rectus abdominis muscle preparation. Methylpentynol has no direct effect on this preparation in concentrations up to 20 μgm./ml. (approximately seven times the maximal amount expected in the extracts), nor does it sensitize the muscle to acetylcholine. The results are shown in Table 1.

Table 1. Effect of Methylpentynol on Acetylcholine Content of the Rat's Brain

Intraperitoneal dose (mgm./kgm.)	Killed (min. after onset of anæsthesia)	Acetylcholine in brain (μgm./gm. ± S.E.)
None (2 animals)	—	2·77
200 + 100	4	3·03
300	3	3·19
300	2·8	2·80
300	2·5	3·15
		Mean 3·04 ± 0·17
None (6 animals)	—	3·05 ± 0·23
500	12	5·88
500	15	5·08
500	12	5·83
500	15	4·55
500	12	4·60
500	12	5·10
500	12	5·00
500	12	5·66
		Mean 5·20 ± 0·52

The animals given the lower doses were all lightly depressed, and their acetylcholine-levels were only slightly higher than those of the two control animals. On the other hand, those animals given 500 mgm. of methylpentynol per kgm. were deeply depressed and the levels of acetylcholine in the brain were considerably higher than those of the control animals. It appears that, in rats, methylpentynol causes a rise in the level of acetylcholine in the brain, and that the extent of this rise is related to the degree of depression induced by the administration of the agent. If methylpentynol causes a rise in brain acetylcholine by reducing the output of that substance at certain central synapses, these results would indicate that there is no interference with the synthesis of acetylcholine. It has already been established that methylpentynol does not inhibit cholinesterase (unpublished work).

Since preparing this communication, we have conducted experiments to show that there is no difference in the synthesis of acetylcholine by slices of cerebral cortex from brains of untreated rats and by those from brains of rats under anæsthesia induced by methylpentynol (in a dose of 500 mgm./kgm.).

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Effect of Severing the Olfactory Bulbs on the Intake and Excretion of Water in the Rat

Ecologists and experimental workers maintain that the sense of smell plays an important part both in the search for food and the regulation of alimentary reactions[1–3]. In recent investigations we studied the significance of olfactory signalization for the intake and excretion of water.

Adult male rats in groups of eight or more were used. The skull was trephined above the olfactory bulbs and the bulbs severed with a scalpel: the experiments were begun after a period of 1–2 months. Control animals were sham operated. During the experiment animals were housed individually in metabolism cages, and the intake and excretion of water together with food intake and body-weight were determined.

In the animal house operated animals drink 71 per cent more water a day than normal animals, and the same result was obtained during the experimental period: after their olfactory bulbs had been cut, rats drank 60 per cent more water in a day than the control animals and also excreted 60 per cent more urine. Thus water exchange was the same for both groups.

In order to determine whether increased water intake or increased water loss was the primary mechanism concerned the following experiment was performed. Animals housed in metabolism cages were deprived of food and water for 24 hr. and the amount of urine excreted was measured. It could be shown that operated animals lost 65 per cent more water than control animals during that period.

It seemed possible to explain the above findings by assuming a defect similar to diabetes insipidus. In order to confirm this assumption, adiuretic activity was determined in the blood of our animals using the method of Heller[4]. Its activity was found to be significantly lower in the blood of operated animals than in that of the controls. Exclusion of other sensory receptors (enucleation, severing of the trigeminal nerve) has no effect on water metabolism. Thus severing the olfactory bulbs significantly affects the intake and output of water. It has no effect on food intake and body-weight.

In further experiments it was shown that normal rats make up for the deficit in water due to the 24-hr. period of starvation and thirst by increasing their intake of water on the next day. Operated animals react quite differently. They drink the same amount of water as before the period of thirst. After 24 hr. without access to food and water, control rats excrete urine in the normal fashion. Operated rats under the same conditions urinate less than normally. Only on the next day and afterwards do we find the high excretion of water observed before the period of starvation and thirst. This was also confirmed by a further experiment. Animals were again deprived of food and water for 24 hr. and then given a quantity of water at 38° C. through a stomach tube corresponding to 5 per cent of their body-weight. 3 hr. after the administration of water it was found that more water was retained by the operated rats than by the control ones, the former excreting 40 per cent less water than the latter. It may be concluded that intact rats regulate a water deficit by an increased intake of water, while operated animals react by decreasing urine excretion. Thus these animals, although having less adiuretic activity in their blood, are capable of regulating the volume of their body-fluid.

The changes described do not appear immediately after the operation and on the average become permanent after 20 days. This demonstrates that they are not due to surgical trauma or exclusion of olfactory signalization. It is assumed that they depend on degenerative changes in the olfactory tracts leading to the hypothalamus whence collaterals pass to hypothalamic nuclei. This will have to be verified.

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Interrelation of Tryptophan and Nicotinic Acid in Man during the First Month of Life

In the fœtal liver of mammals there is little or no activity of the following enzymatic systems: glucose-6-phosphatase[1], uridine diphosphoglucose dehydrogenase, and glucuronyltransferase[2], phenylalanine transaminase, tyrosine transaminase and phenylalanine hydroxylase[3]. Hence these enzymes reach the normal levels of activity during the first period of extra-uterine life, and for some of them it seems that this process is regulated or accelerated by the adrenocortical hormones.

A similar behaviour has been demonstrated in the rat, in the guinea pig, and in the rabbit as regards the tryptophan peroxidase activity[4]: in the fœtus and newborn of these animals, the conversion of tryptophan into nicotinic acid is diminished or completely eliminated.

We have recently begun an investigation of the tryptophan metabolism in sucklings. In the work to be described in this communication, our particular interest was to examine, in newly born children and sucklings 1 month old, the excretion in the urine, both spontaneous and after administration of L-tryptophan, of the intermediary metabolites of the conversion of this amino-acid to nicotinic acid.

We examined urine samples of normal newly born children and of normal sucklings. The urine was taken every other day, from the first to the thirtieth day of life. For the chromatographic analysis of the urinary metabolites involved in the tryptophan–nicotinic acid system the Dalgliesh technique[5] was used.

Urine samples of 5 breast-fed and of 5 hand-fed children, without administration of L-tryptophan, have been examined systematically during the whole of the first month of life.

In this way, three types of excretory picture, occurring in succession, were observed. The first is characterized by the absence of the metabolites looked for, and lasts from the first to the fourth–eleventh day, varying from child to child; the second phase lasts from the fifth–twelfth day to the seventh–twenty-eighth day and is characterized by the appearance of numerous conjugates of 3-hydroxykynurenine and kynurenine (R_F 0·1–0·15), and of the kynurenine; in 7 out of 10 cases, of 3-hydroxyanthranilic acid; in 2 cases also of anthranilic acid and of 3-hydroxykynurenine; in some of the children the conjugates and the kynurenine appeared before the 3-hydroxyanthranilic acid. The third phase was characterized by the progressive disappearance from the urine of all these metabolites.

However, of the 10 children examined, one excreted with the urine only traces of the conjugates of 3-hydroxykynurenine and of kynurenine (R_F 0·1–0·15), but never the other metabolites looked for. No significant difference in the excretory picture was found between breast-fed and hand-fed children, with the techniques used.

Finally, 2 children were given L-tryptophan *per os* (the first child 150 mgm. and the second 400 mgm.) in single doses on the second, eighth and thirteenth day of life. Their urine was collected for 24 hr. after administration of the drug. In both subjects the dose given on the second day provoked high urinary excretion of L-tryptophan (detected on paper also with the xanthydrole reaction[6]), without the appear-

ance of any other metabolite in the urine. On the eighth and thirteenth day large quantities also appeared of kynurenine, N-α-acetyl-kynurenine, and 3-hydroxyanthranilic acid.

Our results could be, perhaps, explained by the variations during the first month of life of the renal threshold for tryptophan metabolites; or, more probably, by deficiency of the tryptophan–peroxidase activity during the first days of life. There should be, in succession, within the first month, activation of the tryptophan–peroxidase and of other enzymes which catalyse the conversion of the amino-acid into vitamin; if this should happen, during the first days of life the synthesis of nicotinic acid from tryptophan would be completely, or at least partly, inhibited. As is already known, this metabolic route provides in the adult person the synthesis of some tissue pyridinic coenzymes[7].

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Coenzyme *A* Content of Adipose Tissue

Adipose tissue, long considered an inert storehouse, has recently been shown to have intense metabolic activity. In spite of the importance of coenzyme *A* in fat metabolism, the existence of coenzyme *A* activity had not been demonstrated in adipose tissue. The present communication does so and in addition directs attention to the differences in this respect between normal and obese animals and, among the latter, between animals with 'regulatory' obesity and animals with 'metabolic' obesity[1,2].

The mice used were hereditarily obese hyperglycæmic mice[1,2], approximately five months of age, weighing 51–71 gm., with a blood glucose ranging from 175 to 301 mgm. per cent (av. 242); their thin litter-mates (weight 21–27 gm., blood glucose 82–130 mgm. per cent, av. 93); and thin litter-mates in which hypothalamic obesity had been induced by an intraperitoneal injection of goldthioglucose (crystalline aurothioglucose-*GT*-7-*D*-7-11, Schering Corp., Bloomfield, New Jersey) (1 mgm. per 1 gm. body-weight) two months prior to death (weight 44–58 gm., blood glucose 100–245 mgm. per cent, av. 168)[1–3]. The first two groups were females, the goldthioglucose groups half males, half females (no sex difference in coenzyme *A*-levels was noted).

All animals were kept in separate cages at 26° C., under regular illumination, maintained on 'Purina chow'. Food intakes were checked during the twenty-four hour period preceding death to ensure that animals were in the fed state.

The coenzyme *A* assay method of Novelli[4] was used. This technique is based on the *in vitro* acetylation of sulphanilamide in an artificially defined medium in which coenzyme *A* is the limiting factor. The enzyme source is a bicarbonate extract of a pigeon liver acetone preparation obtained from Cambridge Biochemicals. The animals were killed by a sharp blow on the head; the abdominal fat was quickly excised, weighed, chilled and homogenized in ten volumes of iced water. The homogenate was boiled for 5 min., cooled (ice bath), centrifuged (10 min. at 1,800 r.p.m.), the lipoid foam discarded and the supernatant stored at −4° C. until assayed. Dry weight was determined by the constant-weight method (90° C. oven); nitrogen content (water-soluble) by alkaline nesslerization[5] of an aliquot of the homogenate removed before the boiling using a 45-min. digestion with a modified Arnold–Gunning digestion mixture (sulphuric acid, 20 ml.; potassium sulphate, 10 gm.; copper sulphate, 0·1 gm.), followed by addition of alkaline Nessler's solution (Fisher Scientific dil. 1 : 2 with 10 per cent sodium hydroxide). Solutions are read at 420 mμ. Results are given in Table 1.

Table 1. Coenzyme *A* Levels in Abdominal Fat Tissue of Mice

Type of animal (number per group)	Weight when killed (gm.)	Coenzyme *A* levels (Lipmann units)		
		per gm. wet weight	per gm. dry weight	per 100 mgm. nitrogen (water-soluble protein)
Goldthioglucose obese (9)	45 ± 5	50·89 ± 10·50	62·03 ± 21·30	30·26 ± 6·20
Obese-hyperglycæmic (9)	62 ± 3	40·96 ± 8·26	51·07 ± 20·35	38·80 ± 3·20
Non-obese littermates (8)	26 ± 3	79·12 ± 11·08	108·56 ± 25·65	20·59 ± 6·23

Figures after ± are standard deviations.

It was found that: (1) the coenzyme *A* is present in considerable amount in adipose tissue; (2) the coenzyme *A* activity per mgm. nitrogen is significantly greater in goldthioglucose obese mice than in non-obese litter-mates; (3) the co-enzyme *A* activity per mgm. nitrogen is significantly greater in the hereditarily hyperglycæmic obese than in non-obese littermates made obese by goldthioglucose administration. The last fact is in accord with the known extreme activity of adipose tissue in this syndrome[6].

If values previously obtained for body composition in non-obese mice and mice with the two obese syndromes[7] are accepted, and if it is assumed that the adipose tissue of the animals is homogeneous with respect to the coenzyme *A* concentration, the total coenzyme *A* content (Lipmann units) would be: non-obese 100–150 units, obese-hyperglycæmic approximately 1,200 units and goldthioglucose mice 600–700 units.

An attempt was made to demonstrate the presence of the entire acetylation system (enzyme and co-factors as well as coenzyme) in adipose tissue. The procedures of Lipmann[8] and of Luukkainen[9] were used. No activity could be demonstrated in intact tissue 'cuttings' or in 'unfortified' homogenates. Some activity was seen when a 10-vol. homogenate was incubated for 2 hr. with the 'assay mix' fortified with adenosine triphosphate prepared according to the coenzyme *A* method of Novelli[4].

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Control of Colour Change in Amphibians

THE adaptation of colour in anurans to the background is controlled by hormones. Direct innervation of the melanophores is of little or no importance in controlling the degree of dispersion of the melanin-containing granules within the melanophores[1]. It is generally agreed that a melanin-dispersing hormone is produced in the pars intermedia of the hypophysis and that this hormone, intermedin, is responsible for the darkening of the skin. It is, however, controversial whether the paling upon transfer to a white, illuminated background is due to the disappearance of intermedin from the blood, or to the secretion of a whitening hormone.

Hogben *et al.* argue for the participation of a whitening hormone in the colour response to the background[2]. Their theory can be summarized as follows: light-stimulation of the ventral area of retina causes reflex liberation of intermedin; light-stimulation of the dorsal area of the retina causes liberation of whitening hormone. An amphibian (for example, *Xenopus laevis* on which most of their experiments have been made) kept on a black, light-absorbing background and illuminated from above is therefore dark due to liberation of intermedin. When transferred to a white, light-scattering background the animal becomes pale, because now both the ventral and dorsal retina are stimulated, and whitening hormone secreted in addition to the intermedin. The whitening hormone should thus be capable of completely over-riding the melanin-dispersing activity of intermedin. The whitening hormone is assumed to be produced in the pars tuberalis of the hypophysis[2,3]. But also the adrenal medulla[4] and the pineal gland[5] have been considered as sites of origin of a whitening hormone.

In order to decide whether a whitening hormone does or does not participate in the normal control of the colour response to a white, illuminated background, we denervated the neuro-intermediate lobe in *Bufo bufo* and *Xenopus laevis* by cutting, in its entire width, the thin wall of the third ventricle which separates the neuro-intermediate lobe from the median eminence and infundibulum. In some operations, part of the neuro-intermediate lobe was extirpated; in others the lobe was transplanted to an eye muscle. So in all the operations the structures supposed by Hogben *et al.* to control the liberation of the whitening hormone were left intact. The operations exclude a nervous regulation of intermedin secretion, whereas a nervous regulation of secretion of the whitening hormone should still be possible—provided the whitening hormone is not secreted by the neuro-intermediate lobe. If a whitening hormone is released into the blood stream when operated animals are transferred from a black to a white illuminated background, and if the secretion is inhibited on retransfer to a black background, such fluctuations in the rate of secretion might be detectable by observation of the state of the melanin within the melanophores.

Table 1. MELANOPHORE INDEX IN *Xenopus laevis* ON ILLUMINATED WHITE OR BLACK BACKGROUND

		Melanophore index. Background	
		White	Black
X.1	Neuro-intermediate lobe denervated	3·6	3·8
X.2		3·8	3·8
X.3		4·0	3·6
X.4		2·2	3·8
X.5	Neuro-intermediate lobe denervated + partly extirpated	2·4	2·0
X.6		1·7	1·0
X.7		4·0	4·3
X.8		4·0	4·2
	Average of five normal *Xenopus*	1·1	4·3

Readings of the melanophore index were made according to Hogben. Melanophore index of 1 stands for maximally concentrated and of 5 for maximally dispersed melanin within the melanophores. The animals were kept for 24 hr. or more on the white or black background before the melanophore index was read. The background was changed repeatedly, mostly every day. In Tables 1 and 2 each melanophore index represents the average of readings from six or more changes of background.

It appears from Tables 1 and 2 that in seven out of eight *Xenopus* and in twenty out of twenty-one *Bufo* the colour (melanophore index) was independent of the background during some weeks after operation, even when melanin dispersion was submaximal, that is, when secretion of intermedin from the denervated neuro-intermediate lobe was submaximal. (Submaximal dispersion of melanin *in vitro* is produced by

Table 2. MELANOPHORE INDEX IN *Bufo bufo* ON ILLUMINATED, WHITE OR BLACK BACKGROUND

		Melanophore index. Background	
		White	Black
B.1	Denervation of neuro-intermediate lobe	4·9	5·0
B.2		4·3	3·4
B.3		4·9	5·0
B.4		4·9	5·0
B.5		1·4	1·1
B.6		4·5	4·6
B.7		3·3	3·4
B.8		4·9	4·9
B.9		1·8	3·4
B.10–*B*.16*		3·3	3·3
B.17–*B*.19*	Denervation of neuro-intermediate lobe + partial extirpation	2·6	2·9
B.20*	Transplantation of neuro-intermediate lobe	1·8	1·8
B.21		4·1	3·4
	Average of nine normal *Bufo*†	1·3	4·5

* 1–3 readings of melanophore index on each toad on each background.
† *B*.1–*B*.9 before operation.

high concentrations of intermedin[6]. The submaximal dispersion of melanin frequently observed in operated animals was, however, not due to excess secretion of intermedin from the denervated neuro-intermediate lobe, because injection of intermedin into such animals produced maximal dispersion of melanin.) It can therefore be concluded that if a whitening hormone is secreted in response to a white background it is present in the blood in amounts too small to modify visibly the effect on the melanin dispersion of even small amounts of intermedin. Paling upon transfer to a white background must result from the disappearance of intermedin from the blood. The fact that two animals, *X*.4 and *B*.9, did respond to the background after the operation does not necessarily disprove this conclusion. The persisting colour response can be due to incomplete denervation of the neuro-intermediate lobe.

It is generally agreed that intermedin secretion from the pars intermedia is controlled by inhibitory nerves, because lesion of hypothalamus or transplantation of the pars intermedia has been observed to darken the operated animal permanently[7]. We found, however, that the rate of intermedin secretion from a denervated neuro-intermediate lobe can vary from high to zero, as judged from the state of the melanophores. The toads especially operated during the breeding season were pale after the operation. The normal secretion of intermedin is therefore probably regulated by both inhibitory and secretory nerves.

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HÆMATOLOGY

M_1, a Subdivision of the Human Blood-Group Antigen M

A 'new' antibody, anti-M_1, has been found as a component in six out of twenty available human anti-M sera: in one of them practically all the antibody was anti-M_1. No anti-M_1 could be detected in anti-M sera from eight rabbits and from one horse, nor in an extract of the seeds of *Iberis amara* (which contains anti-M): nor could it be found in a wide range of other antisera. We are calling the antibody anti-M_1, because in several ways it behaves like anti-A_1 of the ABO system and anti-P_1 of the P system.

The corresponding antigen, M_1, differs qualitatively from ordinary M. It is not merely strong M, because our two best anti-M_1 sera are insensitive to the greater amount of M known to be present in cells representing the genotype *MM* than in those representing the genotype *MN*; and, conversely, because two anti-M sera in our collection which are particularly sensitive to this 'dosage' difference make no distinction between M_1 and ordinary M. The Ss antigens do not appear to be playing a part in the M_1–M_2 difference.

Preliminary tests established that the antigen M_1 is commoner in Negroes than in Whites: they also showed that there is considerable variability in the strength of the antigen and that the classification of the weaker reactions may be left in doubt. Because of this difficulty we decided to confine the present report to classifications based on the results of rather laborious quantitative tests in which strictly comparable cell samples were used. When better anti-M_1 sera are available we hope it will be possible to classify routine cell samples without using quantitative methods.

Samples of blood from 32 New York Negroes and 32 Whites were taken on the same day at the Knickerbocker Foundation and sent by air to London. There they were tested against titrations of six sera containing anti-M and anti-M_1 in different proportions, and against titrations of three anti-N sera, one anti-S and one anti-s. The results given in Table 1 indicate that M_1 is about four times more frequent in Negroes than in Whites.

Table 1. Results of Testing Samples of Blood from 32 Negroes and 32 White People with Anti-M_1

		Negroes			Whites		
		M	MN	N	M	MN	N
Anti-M_1	+	3	5	0	2	0	0
	−	4	12	8	8	15	7

A genetic background for these antigenic differences can be provided most simply by postulating three alleles, M_1, M_2 and N, the approximate frequencies of which are:

	M_1	M_2	N
Negroes	0·13	0·35	0·52
Whites	0·03	0·52	0·45

Recombined, these figures give expectations in the five phenotype (six genotype) classes which agree very closely with the numbers observed in both the Negro and the White series. This, to say the least, does not contradict the hypothesis that two kinds of *M* alleles are responsible for the M_1–M_2 antigenic difference; but we hope for more direct support when appropriate families can be tested.

We wish to thank Dr. Gerald E. Fox and Sister M. Gabriel, O.S.F., of the Blood Bank, St. John's Hospital, Springfield, Illinois, for sending the serum which first attracted our attention to the M_1–M_2 difference. Other acknowledgments will be made in a more detailed account which will be submitted for publication elsewhere.

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Separation of the α- and β-Chains of Globins by Means of Starch-gel Electrophoresis

THE investigation of the molecular weight and the electrophoretic behaviour of globins at *p*H 2–4 has led to a better understanding of the structure of the hæmoglobin molecule. At a *p*H less than 6 there is a progressive decrease of the molecular weight of human hæmoglobin[1]. At *p*H 11 the value of the sedimentation coefficient is 2·55, which points to a molecular weight of about 33,000 instead of 67,000, a value normally found[2].

In an indirect way, Singer and Itano[3] demonstrated that the dissociation at a low *p*H is asymmetrical. Moving-boundary electrophoresis at *p*H 11[3] leads to the assumption that the molecule is split into two identical halves[2].

Reichmann and Colvin[4] estimated a molecular weight of 16,000 at *p*H 2 for horse globin. From the electrophoretic behaviour of globin in acid medium, these authors were able to show that more than one component was present.

Haug, Smith and Wilson[5,6] were able to isolate two different components from horse globin, by fractionated precipitation with acid acetone, by moving boundary electrophoresis and by a chromatographic procedure at low *p*H. Hunt[7], using the same chromatographic method, separated the α- and β-chains and the α- and γ-chains, respectively, of human adult and fœtal globin. Hill and Craig[8] prepared the α- and β-chains by a counter-current distribution procedure.

This communication is a description of the separation of human adult and fœtal globin in chains by means of starch-gel electrophoresis according to Smithies[9], in formate-buffer *p*H 1·9; $\mu = 0{\cdot}02$. A potential of 120 V. was applied during 16 hr. Globins were prepared[10] from the following hæmoglobins: (*a*) normal adult; (*b*) chromatographically pure A_1[11]; (*c*) fœtal purified by the alkali-denaturation method of Chernoff[12].

The electrophoretic pattern of adult globin (Fig. 1*d* and *e*) demonstrates two fast-moving bands of almost equal intensity, and a third band with a smaller mobility. The fast-moving bands are the α- and β-chains of the globin; this was proved in the following way. Globin was separated into two fractions, the α- and β-chains, using the chromatographic method of Wilson and Smith[6]. After concentration the two fractions were separately applied to the gel (Fig. 1*b*, *c*). Fraction I (α-chain) contains the slower of the two fast bands while fraction II contains the faster band.

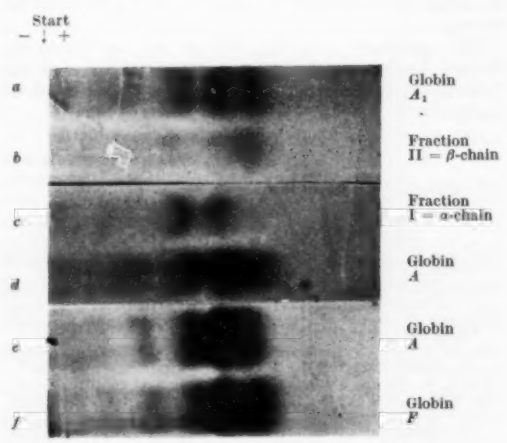

Fig. 1

The electrophoretic pattern of fœtal globin (Fig. 1*f*) compared with the pattern of adult globin (Fig. 1*e*) demonstrates that the α-chains have the same mobility. The mobilities of the β-chains, however, are different. This result is in agreement with the recent findings of Hunt[7].

The nature of the slow band that is present in both separated fractions and in the unfractionated globins is not quite clear. It is possible that they are the result of agglomeration of single chains. Interesting in this respect is the presence of the same band in the electrophoretic pattern of globin of pure hæmoglobin A_1. This excludes the possibility that it is due to the minor components present in the hæmoglobin of an adult human individual. Further research on this third fraction is in progress.

I am much indebted to Prof. J. H. P. Jonxis and Dr. T. H. J. Huisman for their advice and encouragement during this investigation. This work was supported by a grant from the Dutch Organization of Pure Research (Z.W.O.).

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Haptoglobin Types in *Macaca irus*

WE have examined the haptoglobin types[1] of ten Cynomolgus monkeys (*Macaca irus*, F. Cuv.). The serum samples have been obtained from the Department of Virus Research, Karolinska Sjukhuset, Stockholm. The monkeys were not born in captivity, but were all captured from wild populations.

The sera were examined by starch-gel electrophoresis, using the discontinuous buffer system described by Poulik[2]. Hæmoglobin from the monkeys was added to the sera prior to electrophoresis, and the resultant gels were stained with benzidine and amido-black.

The resulting protein patterns were, as expected, similar to human serum protein patterns. Two different hæmoglobin-binding serum protein patterns were observed. Double runs revealed that the two patterns were identical with the *Hp* 1–1 and *Hp* 2–1 types found in man. Three of the ten individuals had the *Hp* 2–1 type. It was noted that the *Hp* 2–1 types had a much heavier concentration of haptoglobin in the fastest zone compared with the ordinary human *Hp* 2–1; in other words, it resembled the *Hp* 2–1 (mod), cf. Giblett[3].

Arends and Rodriguez[4] have examined the sera from 27 monkeys (23 *Macaca mulatta*, 1 *Macaca irus*

and 3 *Cebus nigrivittatus*). All the monkeys were found to have type *Hp* 1–1. The authors suggested that this might be a phylogenetically significant finding, should future investigations confirm that monkeys have only one type of haptoglobin.

The slow-migrating zones of our three heterozygotes were very weak. Such weak types may be overlooked and classified as *Hp* 1–1, especially as the fastest zone is very strong.

The findings by Arends and Rodriguez[4] and our distribution (seven *Hp* 1–1 and three *Hp* 2–1) indicate that the frequency of the *Hp*–1 gene may be high in monkeys. It is then quite reasonable that no *Hp* 2–2 type has yet emerged.

It is known also that African Negroes have a high frequency of the *Hp*–1 gene (refs. 3, 5). Hence this gene might have a selective advantage in tropical areas.

We wish to thank Prof. S. Gard, of Stockholm, for supplying us with the serum samples.

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A Re-Evaluation of the Clotting Time of Chicken Blood

The blood coagulation mechanism of the chicken appears to differ greatly from that of mammals, in that its clotting time can exceed 1 hr. Recent literature assumes the chicken to have a blood-clotting time in a range similar to the higher mammals. Dukes[1] quotes Amendt (1922) as finding this to be 4·5 min.; Johnson and Connor[2] found an average of 6 min. 21 sec. with a range of 1–14 min.; while Didisheim *et al.*[3] query their recorded time of 9 min. in glass and 10 min. with siliconized equipment at 37° C. Howell[4], however, in 1909 infers that it is common knowledge that the blood of birds, terrapins and horses clots slowly. In 1940[5] he indicates that prolonged clotting time of hours or days in lower vertebrates (birds, reptiles and fishes) is due to the lack of "thromboplastic substance" within the vessels while prompt clotting is brought about by an active "thromboplastic tissue extract".

In a preliminary determination of clotting times on fifteen chickens using the Lee and White method[6] with plastic or siliconized glass syringes, a range of 1·5–30·0 min. was found at 42° C. It was observed that the negative pressure of the syringe caused a 'fluttering' of the fragile vein against the bevel of the needle and that the greater the degree of 'fluttering', the shorter was the clotting time of the blood. It was assumed from this that the trauma caused by the vein striking the needle released tissue thromboplastin which hastened clotting.

Blood from thirty-seven caged laying hens of three different breeds (Leghorns, Light Sussex and White Rocks) was collected utilizing precautions to minimize the release of tissue thromboplastin. This was done by venipuncture with No. 20 siliconized *B–D* vacutainer needles only. No syringe was used, the blood

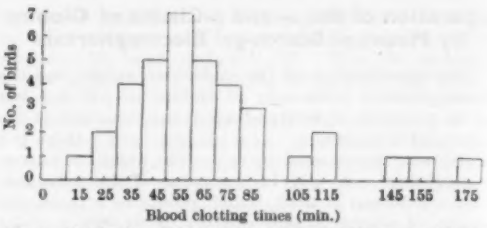

Fig. 1. Distribution of blood clotting times of thirty-seven chickens

being allowed to flow directly into 13 mm. × 10 cm. Kimble glass tubes by very slight digital pressure on the superior portion of the brachial vein. Needle movement within the vein was minimized. Clotting times varied from wing to wing, also between the two tubes from each wing; the longest for each bird ranged from 13 to 180 min. with a mean of 69·25 min. (*S.D.* 36·6) (Fig. 1).

Native blood was also timed with a stop watch following the addition of (1) 0·1 ml. of chicken brain thromboplastin prepared by the acetone dehydration method of Quick[7] and (2) 0·1 ml. of chicken thrombin (full strength) made by the technique described by Biggs and Macfarlane[8]. The results are summarized in Table 1.

Table 1. Coagulation Time at 42° C. of Chicken Blood with and without Added Thromboplastin or Thrombin

No. of birds	Material added	Clotting time (sec.)	Control Lee–White clotting time (min.)
21	Chicken thromboplastin	13·4 (11–17·8)	70
15	Chicken thrombin	30·6 (19–50)	64·5

These observations tend to confirm those of Howell[4,5] and indicate: (1) that the blood of the birds tested had generated very little plasma thromboplastin; (2) that the chicken has an efficient blood-clotting mechanism, but that it relies on an active tissue thromboplastin rather than plasma thromboplastin as do mammals; (3) that the shorter clotting times noted here and by other authors may have been due to action by vein wall tissue thromboplastin.

The apparently delayed action of the chicken thrombin in Table 1 is under investigation. A comparison of clotting times at 37° C. and 42° C. revealed only a slightly longer time at 37° C.

The assistance of Drs. Ballantyne and Carlson, Messrs. Delbecq and Bacle and Miss Ohlman of the Veterinary Services Branch, Alberta Department of Agriculture, is acknowledged.

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HISTOLOGY

Neurokeratin Network of the Peripheral Nerve Fibre Myelin Sheath as a Centre of Metabolic Activity

THE neurokeratin network has long been regarded by histologists as a fixation artefact; it is figured as such in papers and text-books. Sometimes it is shown as irregular bands radiating through the myelin sheath to the neurilemma, sometimes as a network particularly at the surface of the fibre or around the axon.

However, if fresh unfixed nerve fibres are studied under the interference microscope, an indication that similar structures are present can be seen, which suggests that a network-like structure may be present in the living nerve. Investigations of cryostat sections of fresh unfixed nerves in both transverse and longitudinal section indicated that this network is actually in the form of hexagonal prisms which have one end on the axon and radiate out through the myelin sheath to the neurilemma. The longitudinal faces of these prisms take the form of bands seen radiating through the myelin in transverse and medial longitudinal sections of nerve. The application of Baker's acid hæmatin technique showed that these faces give a positive phospholipid reaction, and osmium-fixed nerve, if extracted with turpentine, shows that the osmium tends to be retained on the faces of the prisms but is extracted from their interiors. Since electron microscopists simply stain overall with osmium tetroxide, perhaps this is why this network has not been described in electron microscope studies of the nerve fibre. On the other hand, the performic acid–Schiff reaction which is claimed to demonstrate unsaturated fats gives a reaction in the spaces which constitute the interior of the prisms. Mitochondrial preparations (Regaud and Schridde methods) of the nerve fibre show that a few bodies giving a positive stain for mitochondria are present in the axon, a number are found around the periphery of the axon and a number are found among the lipid (probably lipoprotein, also giving a positive reaction with these techniques) which forms the faces of the hexagonal prisms—no such bodies are found in the interior of these prisms. Adenosine triphosphatase preparations of fresh unfixed nerve demonstrate that this enzyme is localized in the myelin sheath in the same place as the mitochondrial reaction (that is, in the faces of the hexagonal prisms) and that every phosphate ester (about 20 were tried, including creatine phosphate) used as a substrate was dephosphorylated at the same sites as adenosine triphosphate. Acid phosphatase, on the other hand, was localized exclusively in the axon with the incubation times used. No adenosine triphosphatase or other enzyme activity was observed in the nodes of Ranvier. Studies on oxidative enzymes demonstrated that cytochrome oxidase and succinic dehydrogenase were also located in the same areas as the adenosine triphosphatase. Furthermore, we have also demonstrated that specific cholinesterase is located in and around the axon, and non-specific cholinesterase is located in the faces of the hexagonal prisms.

The 'neurokeratin' network thus not only appears to be present in unfixed nerve but also to be a locus of major metabolic activity. The space within the neurokeratin network, although it contains lipid and ether- and alcohol-soluble material, gives no reaction

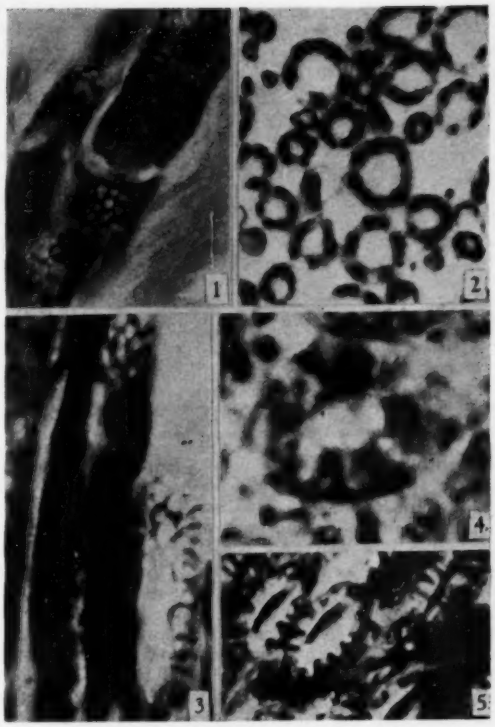

Fig. 1. 1, Adenosine triphosphatase preparation of frog myelinated nerve showing surface view of reaction localized in hexagonal network. On the right of the fibre the plane of section passes through the myelin sheath and the faces of the hexagonal prisms are shown as adenosine triphosphatase-positive bands radiating from the axon to the neurilemma. The node of Ranvier can be seen to contain no adenosine triphosphatase activity. (Preparation and photograph by David G. Shand) (× 1,050). 2, Mitochondrial preparation (Regaud's method) of myelinated nerve of rat. Transverse section. The reaction can be seen to be localized in bands which represent the faces of the hexagonal prisms (× 1,050). 3, Phospholipid preparation (Baker's method) of longitudinal section of myelinated nerve of rat. At the top of the figure the hexagonal appearance of this reaction (surface view) can be seen and further down, where the myelin sheath has been cut, the positive faces of the hexagonal prisms in the myelin sheath are visible (× 1,050). 4, Cytochrome oxidase preparation of a cryostat section of a transverse section of a single unfixed untreated nerve fibre of rat showing the reaction in the form of bands (the faces of the hexagons) radiating out from the axon to the neurilemma (× 2,100). 5, McManus sudan black *B* stain for compound lipids. Transverse sections of nerve fibres of rat. The reaction can be seen to extend in bands radiating out from axon to neurilemma (× 1,050)

with the mitochondrial techniques and contains no dephosphorylating or oxidative enzyme activity. Fig. 2 is an artist's impression of the arrangement of the metabolically active hexagonal prisms in the myelin sheath. It can be seen from this how either transverse or longitudinal sections of the nerve fibre will show the faces of the prisms as bands radiating out from the axon to the neurilemma and how, according to the point of section, some of the bands will appear thick and others thin. The faces of these prisms contain phospholipid, mitochondrial-like lipoprotein, adenosine triphosphatase, creatine phosphatase and a spectrum of other phosphatases, cytochrome oxidase, succinic dehydrogenase, and non-specific cholinesterase.

The possibility that these reactions are artefacts due to freezing, handling or other manipulation has been carefully considered. We feel that the results of our interference microscope studies indicate,

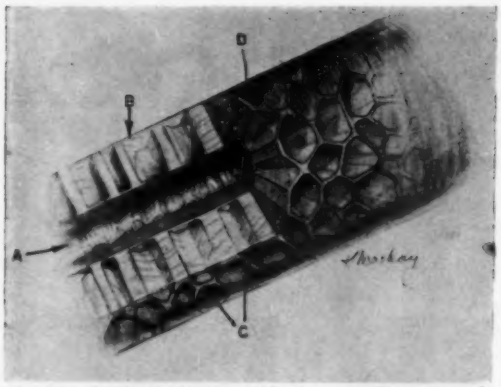

Fig. 2. *A*, Canal normally occupied by the axon; *B*, neurilemmal sheath; *C*, end-on view of faces of hexagonal prisms seen from surface of the nerve; *D*, face of hexagonal prism as seen in transverse section of nerve

though not with absolute clarity, that some structure similar to what we have described may be present in the fresh nerve. Furthermore, our adenosine triphosphatase, cytochrome oxidase and succinic dehydrogenase reactions were carried out on fresh nerve which was simply removed from the animal and dropped straight into the substrate solution. However, all these processes have involved some handling and to compensate for this we have exposed the sciatic nerve in a living, anæsthetized rat without touching or stretching it and dropped buffered osmium tetroxide directly on to it as if we were preparing the material for electron microscopy. After the nerve had been well fixed *in situ*, it was removed, given further fixation in osmium tetroxide, sectioned and the sections were then extracted with turpentine and diacetin—we were able to bring up the neurokeratin network in the form described in this communication. We feel, therefore, that the evidence for the *in vivo* existence of such a network is strong.

It is perhaps inappropriate to speculate on the significance of this structure at this time; but perhaps we should mention that if the efflux of sodium and influx of potassium through the myelin sheath itself is important to nerve function and maintenance of membrane potentials, the faces of these hexagons are admirably adapted for this purpose. Conway[1,2] has suggested a redox system for the active transport of sodium ions by adsorption of these ions on to a catalyst molecule. The present work suggests that the catalyst molecules may be phospholipid, and it is of interest that Conway[3] has himself suggested that this may be so. Creatine phosphatase, adenosine triphosphatase and oxidative enzymes as required by Hodgkin[4] for his ion-pump mechanism are also present in these faces and their possible relationship to the physiology of the nerve fibre should therefore be carefully considered.

In the interpretation of these findings we have not taken into account the lamellæ which electron microscopists have described in the myelin sheath, although it is possible from our osmium tetroxide results that there is simply a stronger binding between the lipid and the protein components of the lamellæ in the regions which we have described as the faces of the hexagons. Nerve fibres from the following animals were used in this study: frog, mouse, rat, cat, dog and human.

The work will be published in detail elsewhere. It was carried out under grant *B*-1914 from the National Institute of Neurological Diseases and Blindness, U.S. Public Health Service.

Note added April 20. While this communication was in the press Wolfgram and Rose[5] have demonstrated the presence of alkaline phosphatase, 5-nucleotidase (confirming the previous observations of Beckett and Bourne[6]) and adenosine triphosphatase in the neuro-keratin network and Koenig[7] has demonstrated the lipoprotein nature of the network.

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PATHOLOGY

Effect of Antibody and Complement on Volume Control in an Ascites Tumour Cell

When Krebs mouse ascites tumour cells are exposed to the action of rabbit antibodies and complement, the permeability properties of the cells are altered in such a way as to permit rapid equilibration of small molecules and ions between the interior of the cells and the medium[1]. This deprives the cells of the ability to regulate their internal cation concentration, which is necessary for normal control of cell volume (ref. 2 and Tosteson, D. C., and Hoffman, J. F., personal communication). As a result, the cell volume then responds passively to whatever colloid osmotic pressure difference exists between the cell interior and the medium. In ordinary media, the colloid osmotic pressure of which is lower than that of the cells, the cells take in water[3,4]. As they swell, they lose protein and ribonucleic acid to the medium[1], probably until the colloid osmotic pressure inside the cells is reduced to that of the medium, when cell volume is stabilized at a new value.

Fig. 1 shows the result of an experiment in which rabbit anti-tumour γ-globulin and complement (fresh rabbit serum) were permitted to act on a washed suspension of ascites tumour cells in a bicarbonate-buffered balanced physiological salt solution containing varying concentrations of crystalline bovine serum albumin (Armour). After 15 min. incubation, a measured aliquot of suspension was placed in a graduated capillary sedimentation tube[5] and centrifuged at 550*g* for 30 min. at 0°. In the absence of added albumin, the antibody-complement treated cells swelled freely, as indicated by an increase of nearly threefold in packed cell volume. At increasing concentrations of albumin the swelling of the cells was progressively reduced, and at concentrations in excess of 110 mgm./ml. the cells were actually smaller than the controls. The volume of the control cells was practically insensitive to changes in albumin concentration, whether antibody was present or not. In most experiments, however, there was a slight increase in packed volume at high albumin concentrations, but this was probably due to poorer

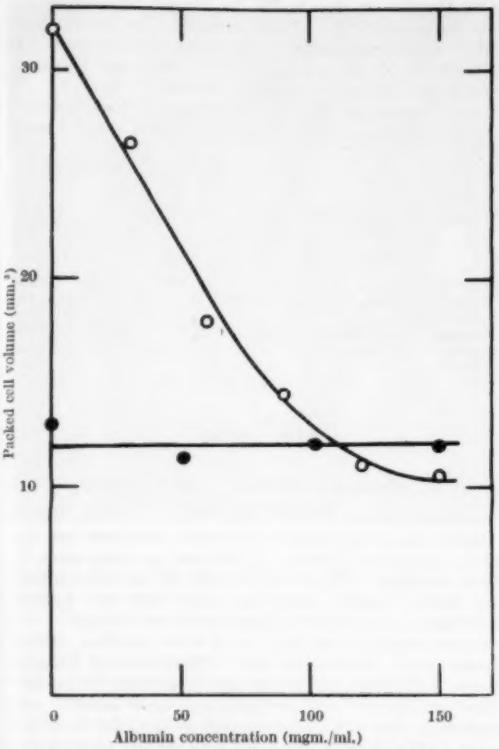

Fig. 1. Effect of albumin concentration on the packed volume of tumour cells treated with antibody plus complement. To flasks containing 0·90 ml. of bovine albumin solutions of varying concentration were added 0·15 ml. immune rabbit γ-globulin (68 mgm./ml.), and 0·15 ml. washed cell suspension ($5·4 \times 10^7$ cells/ml.). To the experimental series 0·30 ml. rabbit complement was then added and to controls 0·30 ml. of heat-inactivated complement. After 15 min. incubation at 37°, while gently shaking in a water-bath, 1·0 ml. aliquots from each flask were placed in graduated capillary centrifuge tubes (ref. 5) and centrifuged.
○, Cells incubated in presence of antibody plus complement;
●, cells incubated in presence of antibody plus inactivated complement

packing of the cells in the denser and more viscous medium.

The decrease in the packed volume of the antibody-complement treated cells with increasing albumin concentration is not due to inhibition of the action of antibody and complement on the cells, since at high albumin concentrations the volume of these cells fell below that of the controls. Moreover, measurement by flame photometry of the potassium ions remaining in the packed cells showed a constant loss from the treated cells of most of their potassium ions over the whole protein concentration range, demonstrating that the antibody and complement had acted on the cells[1].

It appears from Fig. 1 that the colloid osmotic pressure of the cells is equal to that given by a solution containing 110 mgm./ml. serum albumin plus the proteins of the complement and immune γ-globulin. Assuming that globulins contribute half as much to the osmotic pressure as does albumin, the total colloid osmotic pressure would be equivalent to that of an albumin solution of about 130 mgm./ml.

Packed cell volume in these experiments was measured after 15-min. incubation. If, however, cells in albumin concentrations even higher than 110 mgm./ml. were observed in the phase microscope immediately after addition of antibody and complement, a transitory swelling of the cells was observed. After a very few minutes, however, this swelling was arrested and the cells shrank to a size which thereafter remained constant. This transitory swelling may be due to a temporarily more rapid influx of cations than efflux, a hypothesis suggested by Dr. John Cook and supported by the observation that the transitory swelling was largely abolished if sodium ion in the medium was replaced by an equimolar concentration of the larger, more slowly penetrating ion, choline.

It appears, therefore, that for cells which are able to regulate their cation concentrations, cell volume is not detectably sensitive to changes in the albumin concentration in the medium, for the osmotic pressure contributed by even the highest albumin concentration examined, $2·3 \times 10^{-3}$ *M*, is negligible compared with that of the regulated cations. These cells are, of course, shrunk by relatively high molar concentrations of sucrose (0·5 *M*), to which the cell membrane is also impermeable. On the other hand, cells acted on by antibody and complement are not shrunk by sucrose, for the cell membrane becomes freely permeable to small molecules and ions[1]. For the same reason, these cells act as osmometers responding passively to the osmotic pressure of those macromolecules which are sufficiently large so that they cannot pass through the altered cell membrane.

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Changes in the Deoxyribonucleic Acid Content of Mouse Sarcoma 37 Cells following Serial Irradiation

Changes in the deoxyribonucleic acid content of human tumour cells following irradiation have been reported by Richards and Atkin[1] and Atkin, Richards and Ross[2]. There exists strong evidence in support of a positive relationship between modal deoxyribonucleic acid content and the degree of ploidy; this has been discussed by Atkin and Richards[3], and Richards and Atkin[4]. This communication reports changes in content of deoxyribonucleic acid in the mouse sarcoma 37 following serial irradiation.

The tumours selected for study were taken from untreated control transplants and from the twentieth untreated sub-line passage of the twelfth stage of the serially irradiated line (*B*12). Although the irradiated line at this stage varied from the control with respect to histology and cytology, no subsequent variations occurred during sub-line passages. Details of the techniques employed in establishing the irradiated line have been given elsewhere[5]. Smears of isolated cells from the cortex of actively growing tumours were prepared as described by Atkin and Richards[3]. The amount of deoxyribonucleic acid in individual cell nuclei was estimated by microspectrophotometry of Feulgen stained material. Two tumours from each group were used; 72 cells were measured in each of one pair (Fig. 1, *A* and *C*) and 45

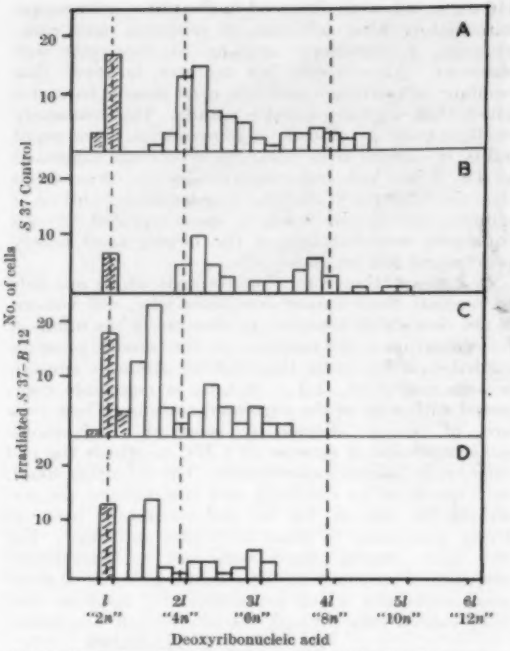

Fig. 1. Measurements of deoxyribonucleic acid in cells of sarcoma 37 and its serially irradiated line *B*12. Shaded regions, leucocytes; unshaded regions, tumour cells

cells in the second (*B* and *D*). In addition, 14–20 polymorphonuclear leucocytes and lymphocytes were measured from each tumour preparation to provide a modal value corresponding to the diploid level (the *l* value).

The results of these measurements are shown in Fig. 1 in the form of histograms having 10 classes between the 2*l* and 4*l* values. Control tumours exhibited a primary mode in the tetraploid region with an extensive spread to the hyperoctoploid region. Irradiated line tumours exhibited a primary mode corresponding to a triploid condition with a less extensive spread towards higher values than was found in control tumours.

It is apparent that the modal deoxyribonucleic acid value of the irradiated mouse tumour line differed from that of the unirradiated control. Radiosensitivity comparisons between the two lines, however, indicated that no changes had occurred in the tumour lethal dose; at lower dose-levels, an increased radiosensitivity was apparent in the irradiated line[5]. It seems, therefore, that the changes observed cannot be correlated with the acquisition by the irradiated line of radioresistant characteristics. In this connexion it is of interest that serial observations on the content of deoxyribonucleic acid of two human cervical carcinomata, which responded poorly to radiotherapy, strongly suggested the emergence following treatment of a stable radioresistant cell strain having in both cases a triploid deoxyribonucleic acid content from what was originally a mixed population[1]. The accumulated data on human uterine tumours[1,2] show that there is no clear-cut correlation between ploidy-level and response to radiotherapy, although near-diploid tumours appear to give rise to fewer local recurrences than do those with higher modal values of deoxyribonucleic acid.

Our thanks are due to Mr. D. Doxey for assistance with the preparation of cell smears. The deoxyribonucleic acid measurements were made in collaboration with Dr. B. M. Richards, at the Wheatstone Physics Laboratory, King's College, London.

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BIOLOGY

Nuclear Morphology of Human Spermatozoa

This communication concerns observations on dried, unstained smears of human spermatozoa in phase contrast. These were made in an attempt to gain more insight into the basis for the known differential in conception and birth sex ratios.

Spermatozoa from forty men were studied. Thin smears were allowed to dry. Observations became clearer with increase in extent of drying. The dry phase objectives and condensers were used. Oil immersion and wet preparations in seminal fluid did not permit observation of nuclear detail, that is, the chromosomes accentuated their own visualization in phase contrast in the dried state. A Zeiss phase-contrast microscope with built-in accessory scope was used. A Leica camera with 'Ibso' attachment and 'Microfile' film was employed.

Under these conditions, lying horizontally, the spermatozoan heads fell into two distinct populations (Figs. 1–3). There were no intermediate types. Reflexion of light was different for the two kinds

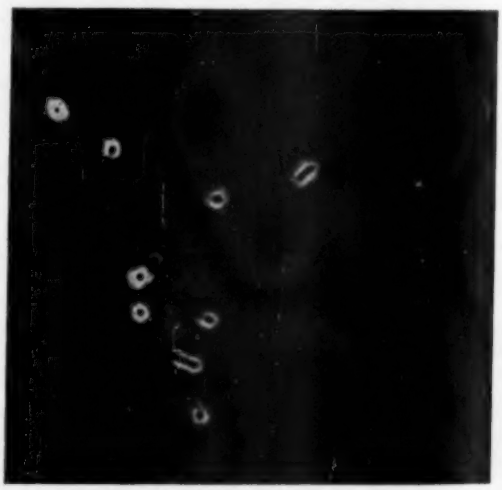

Fig. 1. Dried, unstained smear of human spermatozoa in phase contrast. (× 640)

Fig. 2. Dried, unstained smear of human spermatozoa in phase contrast. (× c. 750)

(Figs. 1 and 2). The smaller-headed spermatozoa contained a centrally located, rounded mass, whereas the larger-headed ones had an elongated mass, centrally located. These masses lay anterior to, and in line with, the axial filament of the mid-piece. There was a definite, constant pattern of nuclear content in each type, conforming in outline to the respective, most central chromosome (Fig. 3). In the smaller-headed spermatozoa the nuclear material was arranged with circular concentricity; in the larger-headed ones, the nuclear material had an elliptical or ovoid configuration. The pattern of arrangement remained characteristic and recognizable for each of the two types of spermatozoan heads, in front and side views and while varying the focus. The nuclear content of the larger-headed spermatozoa was less compact; consequently more detail was seen at different focal levels here. In one head of this type three observers counted independently 18 discrete chromosomes at different focal levels. With proper combination of condenser and dry objective the difference in diffraction of light by the chromosomes markedly enhanced their visibility, as though they were stained differentially. This made it possible to photograph them in colour.

The most centrally situated chromosome in each type of nucleus possessed the exact size and shape relationships of the *X* and *Y* chromosomes previously observed in the primary and secondary spermatocytes at metaphase in meiosis (Fig. 3).

Fig. 3. Dried, unstained smear of human spermatozoa in phase contrast. (× 1,000)

Even though the characteristics were remarkably constant for the two types of spermatozoan heads within a given specimen, the overall head-size varied from individual to another. In some donors the respective head-sizes were twice as great as in others. Even though actual percentages were not ascertained for each type in each specimen, it was readily noted that the ratio was not the same in all specimens, and that there was a preponderance of the smaller-headed spermatozoa in each specimen. Further observations are being made on the ratio of the two kinds in a large number of specimens and in varied circumstances.

Any differential in migratory rate of the two kinds of spermatozoa can now be investigated with ease by means of the capillary tube method[1]. This is now being studied. With the two distinct types now recognizable, the efficacy can be checked of attempts to separate the *X*- and *Y*-chromosome-containing spermatozoa.

In summary, viewed in phase contrast, dried, unstained spermatozoa fall into two distinct populations regarding head and nuclear size, shape, diffraction of light and chromosomal pattern. With knowledge of the behaviour of the sex chromosomes at metaphase of the meiotic division of the primary and secondary spermatocytes, the relative sizes and shapes of the chromosomes in the centre of the spermatozoan nuclei indicate that the smaller heads contain the *Y*- and the larger the *X*-chromosome.

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Dependence of the Sex Ratio at Birth on the Age of the Father

Recently I have attempted to develop a general theory of ageing applicable to mammals[1]. This theory assumes that, during the life-time of the animal, whole chromosomes, which are contained in the somatic cells, suffer a total loss of function in a single random event. It further assumes that the probability of such an event remains constant throughout life-time and that it is the same for all individuals of a given species.

From the American life-tables I have derived, on the basis of the theory, the frequency with which such random events occur in man and found that on the average one chromosome, of the haploid chromosomal set of the somatic cell, suffers such a 'hit' in about twelve years. If we assume that this holds also for the spermatogonia in man, we should then expect that the ratio of boys and girls, at birth, decreases appreciably with the age of the father. This conclusion is based on the following notions:

We may assume that any cell of the male becomes non-functional if the *X* chromosome for which the cell is hemizygous suffers an ageing hit, that is, the absence of the *X* chromosomes is lethal for the somatic cell in the male. The absence of the *Y* chromosome is not lethal for the somatic cell and, as a matter of fact, it need not be lethal even for the zygotes; there exist individuals whose cells contain one *X* chromosome and no *Y* chromosome and these exhibit Turner's syndrome.

Accordingly, if the *X* chromosome in a spermatogonium suffers an ageing hit, then the cell is eliminated; if the *Y* chromosome in a spermatogonium suffers an ageing hit, then the cell remains fully functional and will give rise to spermatozoa, but only to spermatozoa which contain an *X* chromosome.

The length of the *Y* chromosomes amounts to about 3 per cent of the total length of the haploid set of the autosomes[2] and on this basis we may perhaps assume that an average of 2 per cent of the *Y* chromosomes of the spermatogonia suffer an ageing hit in a 12-year period.

We may assume that some spermatogonia are lost due to causes other than ageing and are replaced by other spermatogonia undergoing divisions. Then if spermatogonia which lack a functioning *Y* chromosome divide at the same rate as spermatogonia which carry a functioning *Y* chromosome, the ratio, at birth, of boys and girls would decrease by 2 per cent for a 12-years increase in the age of the father, and by 4 per cent for a 24-years increase. However, if the spermatogonia which lack a functioning *Y* chromosome undergo divisions at a somewhat lower rate, then the ratio of boys and girls would, initially, decrease with the father's age at the rate quoted above, but the ratio would approach a fixed value with increasing age of the father.

One may compute on the basis of birth data[3] for the United States, 1955, the dependence of the ratio of boys and girls on the age of the father. For the age-group of the father indicated and for the sample sizes—for boys alone or girls alone—given in brackets, the ratios are as given in Table 1.

Table 1

15–19 yr. (~ 46,000): 106·7;	20–24 yr. (~ 410,000): 105·7;
25–29 yr. (~ 500,000): 105·0;	30–34 yr. (~ 440,000): 105·0;
35–39 yr. (~ 250,000): 105·0;	40–44 yr. (~ 120,000): 104·1;
45–49 yr. (~ 45,000): 103·6	

These data do not take into account the age of the mother, and there is, of course, a strong correlation between the age of the father and the age of the mother. What one would want to know is the dependence of the sex ratio at birth on the age of the father, for a fixed age of the mother. However, if one tabulates the available data on this basis the sample sizes become too small.

From the data given in Table 1 it would appear that the ratio of boys and girls does fall with increasing age of the father. It will not be possible, however, to draw conclusions which are relevant from the point of view of the theory until the data based on larger samples become available.

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Neuro-Muscular Transmission in the Earthworm

Neuro-muscular transmission was investigated in the earthworm, *Lumbricus terrestris*, by stimulating a segmental nerve with maximal shocks and recording the electrical responses from the surface of the longitudinal muscle.

A single action potential was recorded to each shock, and from latent period measurements it was calculated that conduction velocity in the motor neurones was of the order of 0·4 m. per sec. This slow velocity suggests that, unlike the situation in *Myxicola*[1] and certain other polychaetes[2], there are no rapidly conducting giant axons in the segmental nerves of *Lumbricus*.

At frequencies greater than 1 per sec. the first muscle potential was found to be consistently smaller than subsequent ones (Fig. 1). In a very few preparations there was a gradual increase in size over the first three responses. In greatly fatigued preparations the response to the first shock was much reduced, though never completely absent, and the difference between the first and second responses particularly marked.

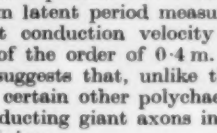

Fig. 1. *Lumbricus terrestris*: longitudinal muscle potentials in response to repetitive stimulation of segmental nerve at three shocks per sec. Tracing of original oscillograph record. Each potential preceded by upward-projecting stimulus artefact

If the frequency of stimulation is gradually increased the size of the muscle potentials also increases. For example, in one preparation (Fig. 2) the segmental nerve was stimulated initially at just less than one shock every 2 sec. and the approximate height of the muscle potentials, measured from the oscillograph trace, was 7·5 mm. The frequency was then increased to 3 per sec. and the muscle potentials rose to 13 mm., being maintained at about this height until after several seconds the frequency was decreased again.

Fig. 2. *Lumbricus terrestris*: longitudinal muscle potentials in response to repetitive stimulation of segmental nerve at gradually increasing frequency. Tracing of original oscillograph record. Each potential preceded by upward-projecting stimulus artefact

With prolonged repetitive stimulation the potentials, after being maintained for a short while, undergo a gradual decline in magnitude, the number of shocks required to induce fatigue depending on the frequency of stimulation and the freshness of the preparation.

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Determination of Physiological Age for Female *Glossina morsitans*

RECENTLY, considerable attention has been paid to a method of determining the physiological age of female insects of economic importance by the appearance of the ovarioles after ovulation. This method, which was originally worked out by Soviet entomologists[1,2] for *Anopheles*, and has since been extended to other blood-sucking Diptera, depends upon the recognition of the number of follicular relics ('corpora lutea') appearing as dilatations of the follicular tubes. Each dilatation represents the relic of a single egg follicle and is evidence of a gonotrophic cycle. If the duration of the cycle is known it is possible to calculate the calendar age of the female, a factor of great practical application in determining the epidemiological importance of populations of insect vectors or the degree of success of control programmes. In the laboratory, Bertram and Samarawickrema[3] recognized *Mansonioides uniformis* which had completed five gonotrophic cycles by the presence of five dilatations in the follicular tubes. A study of the ovarioles of *Glossina morsitans* after ovulation has been made, and it is suggested that a similar method of determining the physiological age of female tsetse flies should be possible.

Each ovary of *G. morsitans* consists of two polytrophic ovarioles, each at a different stage of development[4]. Only one egg matures at a time, and a sequence of ovulation occurs so that the first and third eggs are ovulated from the right ovary and the second and fourth eggs from the left ovary. Subsequent eggs are produced from each ovariole in a continuation of the same sequence.

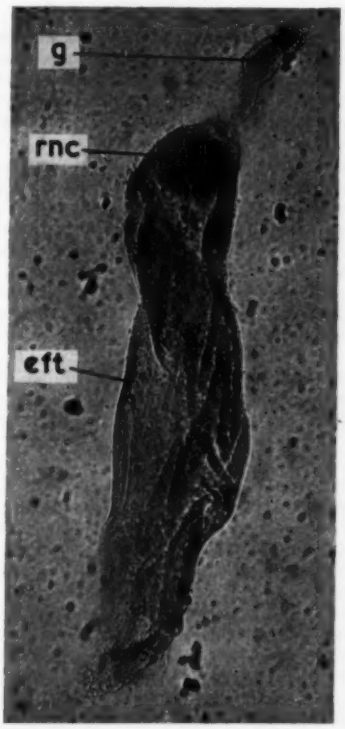

Fig. 1. Ovariole of *Glossina morsitans*, immediately after ovulation of egg. *g*, Germarium; *rnc*, remains of the nurse cells; *eft*, expanded follicular tube

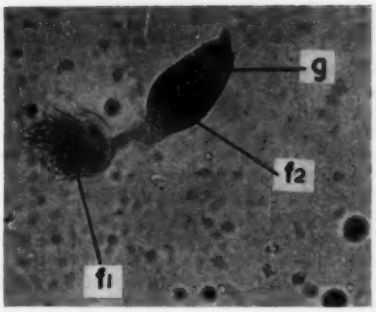

Fig. 2. Ovariole of *Glossina morsitans*, six days after ovulation. *g*, Germarium; *f2*, first signs of second egg follicle developing in the germarium; *f1*, remains of first follicle

Immediately after ovulation the follicular tube of the ovariole, which has been greatly stretched to accommodate the mature egg, is an open expanded sac which retains the remains of the nurse cells and the follicular epithelium (the follicular relic) (Fig. 1). In the next few days the follicular tube begins to contract and the follicular relic is passed out of the ovariole. A greater part of the expanded follicular tube then becomes detached, possibly because the germarium is pushed towards the anterior end of the ovary by the growth of the other ovariole. After four days all that remains of the 'dilatation' is a small piece of tissue remaining on the posterior end of the follicular tube which resembles the 'funicle stumps' of parous *Anopheles gambiae* described by Lewis[5], and is evidence of ovulation (Fig. 2). As a complete dilatation as described for *M. uniformis*[3] is not formed, serial dilatations are never found in *Glossina morsitans*, and ovarioles which have ovulated twice or more cannot be distinguished from those which have only ovulated once. The sequence of ovulation, however, enables the number of eggs produced by a female to be determined up to the production of the fourth egg; after this it is impossible to tell how many eggs have been produced.

At 26° C., the fourth egg is ovulated (from the left ovary) 40 days after the emergence of the fly and therefore, at this temperature, flies may be aged up to at least the fortieth day by the number and position of the funicle stumps and the relative sizes of the four egg follicles. After the ovulation of the first egg (eighth or ninth day at 26° C.) eggs are ovulated about every 10 days, and the uterus contains either an egg or a developing larva. Each of the latter 10-day periods, therefore, may be subdivided by the stage of the offspring *in utero*. It is suggested that a combination of these observations could be used to determine the age of wild-caught tsetse flies.

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Induction Phenomena in Photosynthesis of Isolated Spinach Chloroplasts

In a number of papers concerning the induction phenomena during photosynthesis[1–5] I have determined the interrelationship between time and photosynthetic intensity as expressed by the photosynthesis time-curve. The sample plants used were mainly various species of moss[4]. In most cases the rate of photosynthesis was measured in terms of uptake of carbon dioxide; but in a few cases the rate of oxygen given off was measured as well[3]: the determinations were made by means of the diaferometer method (the gas thermal conductivity method)[1].

Uptake of carbon dioxide sets in immediately the plant material is exposed to light, a peak appearing in the photosynthesis time-curve (Fig. 1, curve *A*). It appears to be reasonable to assume that this is due to the presence of a so-called carbon dioxide acceptor I, which is probably different from ribulose diphosphate, the latter coming into full action somewhat later and consequently being referred to as acceptor II[3,5]. It is further shown that at 15° C. the carbon dioxide taken up is normally transferred in the course of 5–6 min. to acceptor II, or, alternatively, that it enters the assimilation process proper in other ways[2,5]. If the illumination is suspended before this occurs a gush of carbon dioxide appears[2]. If the plants are heated at 40–50° C. for 3 min. prior to the measurements, the photosynthesis proper is found to have been inhibited completely. However, this is not true of the initial uptake of carbon dioxide by acceptor I. Probably a certain degree of inhibition exists in this case as well, but a very distinct peak is still found in the photosynthesis time-curve immediately following the onset of illumination. In these circumstances a gush of carbon dioxide appears when the light is switched off, its value corresponding to the amount of carbon dioxide fixed during the initial uptake. Similar reactions are found in cases where the plants are treated with cyanide, arsenate or iodoacetamide prior to the measurements, or if they are subjected to very high concentrations of carbon dioxide during the measurements[5,6].

In a number of papers, Arnon *et al.*[7–12] have demonstrated the practicability of effecting complete photosynthesis with isolated chloroplasts. They demonstrated the uptake of carbon dioxide in a suspension of chloroplasts to which had been added carbon-14, measuring the radioactivity of the dried chloroplasts[8]. In the present work the same isolation technique was used and by this means I succeeded in directly drawing the photosynthesis time-curve for a preparation of chloroplasts using the diaferometer method.

By means of the above isolation technique[9,10] the chloroplasts are obtained in the form of a suspension in 0·35 *M* sodium chloride. The uptake of carbon dioxide is reported to have been demonstrated by illuminating a mixture of this suspension with a *tris*-buffer solution (*p*H 7·4) to which have been added ascorbate and manganous chloride. Centrifugation of such a mixture in a centrifuge tube containing a piece of filter paper at the bottom results in the fixation of the chloroplasts on to the paper which can then be placed in the plant container of the diaferometer, where they are then exposed to an intensity of 6,500 lux at 15° C. in streaming atmospheric air to which has been added 3 vol. per cent of carbon dioxide. The results appear in Fig. 1. Curve *A* is the

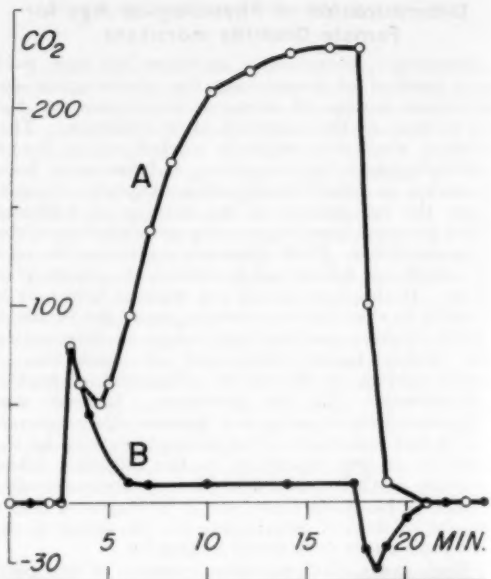

Fig. 1. Photosynthesis time-curves for an intact spinach leaf (*A*) and for isolated spinach chloroplasts (*B*) suspended in 0·35 *M* sodium chloride, added *tris*-buffer (*p*H 7·4), ascorbate and manganous chloride and fixed on to filter-paper. Ordinate, carbon dioxide uptake in arbitrary units; abscissa, time (min.). Black and white areas indicate periods of dark and light on the plant material

photosynthesis time-curve for an intact spinach leaf, and curve *B* is the corresponding curve for isolated spinach chloroplasts in contact with ascorbate and manganese chloride during the measurements.

This curve (*B*) is very reminiscent of the photosynthesis–time curves from intact leaves which had been exposed to heat, had been treated with cyanide, arsenate or iodoacetamide, or which during the measurements proper had been surrounded by air of an excessively high content of carbon dioxide (10–20 vol. per cent). There appear to be two possible explanations of this similarity. First, Arnon *et al.*[10] have shown that even a brief heating of the isolated chloroplasts at room temperature causes a considerable reduction of their ability to fix carbon dioxide on illumination. Hence it would appear to be conceivable that the reaction shown by intact leaves when heated for 3 min. at 40–50° C. in the chloroplast preparation experiments might occur already at lower temperatures. Secondly, although the chloroplasts were surrounded by a liquid containing ascorbate and manganous chloride during the measurements proper the experimental conditions must be considered to have been fairly unfavourable for the photosynthetic turnover[13]. Hence it appears to be permissible to a certain extent to compare them to similar ones which might be assumed to exist during certain toxic conditions when one or more steps in the mechanism of photosynthesis are paralysed.

In this connexion it is worth noting that if the chloroplasts only are suspended in a solution of buffer in 0·35 *M* sodium chloride without the addition of ascorbate and manganous chloride the photosynthesis–time curve shows only the initial peak during the light period and the gush of carbon dioxide during

the terminating dark period, but no uptake of carbon dioxide after the development of the peak. One fact is conspicuous, namely, that although the photosynthesis proper in the chloroplast preparation is comparatively slight the initial peak in the time-curve is very distinct. As in the case of the whole leaves treated in any of the above ways, it may be established in this case also that the amount of carbon dioxide taken up immediately on the onset of illumination remains fixed throughout the duration of the light period, to be liberated afterwards in the form of a gush of carbon dioxide.

Hence the use of the diaferometer method offers the possibility of registering the initial as well as the subsequent uptake of carbon dioxide in isolated chloroplasts. The isotope technique used by Arnon, Allen and Whatley[10], on the other hand, allowed them to register only the amount of carbon dioxide which remains fixed even after the light has been switched off. The preliminary experiments here described appear to confirm the hypothesis mentioned concerning the function of acceptor I immediately upon the onset of illumination. They also show that this acceptor is found in the chloroplasts and that hence it must be considered to be part of the photosynthetic apparatus proper. Further photosynthesis experiments with isolated chloroplasts are in progress and will be published in detail elsewhere.

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Hæmoglobin in the Root Nodules of *Casuarina cunninghamiana*

IN higher plants the respiratory pigment hæmoglobin has been detected only in root nodules of legumes[1,2]; it occurs there in all the species examined when nodulation is initiated by an effective nitrogen-fixing strain of the symbiont *Rhizobium*[3]. The presence of the pigment therefore appears to be possibly connected with the process of symbiotic nitrogen fixation.

Symbiotic nitrogen fixation is not, however, confined to the Leguminosae. Nine genera of Angiosperms, derived from six families, bear root nodules when an appropriate endophyte is present, and the capacity of these nodules to fix nitrogen at high rates is now well established. The quantitative work in this field has largely been carried out by Bond and his colleagues. Bond has recently reviewed the literature on the subject[4,5].

It is therefore not surprising that non-legume root nodules have been examined for the presence of hæmoglobin. Smith (quoted in ref. 6) was unable to detect the pigment in nodules of *Myrica*. Similar negative results were obtained by Egle and Munding[7] with *Alnus*, *Hippophaë* and *Myrica*, but they were able to show that the total hæmatin content of nodules of these genera, estimated as pyridine hæmochromogen, was 4–5 times greater than that of the cortex of non-nodulated roots. This work gave no indication of the manner in which the hæmatin occurs in the living cell. An opportunity to find whether it is present as a hæmoprotein, like all the known functional hæmatin compounds, was presented when Dr. G. Bond generously offered to supply nodulated material from *Alnus*, *Hippophaë*, *Myrica* and *Casuarina*. This had been obtained from plants grown in liquid culture in a medium devoid of combined nitrogen. A spectroscopic re-examination of the nodules seemed especially desirable in view of the high sensitivity of their fixation process to the presence of carbon monoxide[8].

The nodules of all four genera were found to possess a very active phenol oxidase system: the discoloration which occurred when nodules were crushed in water or dilute phosphate buffers hindered, and sometimes precluded, spectroscopic examination. It was found that this discoloration was decreased by using 0·2 *M tris* (2-amino-2-hydroxymethylpropane-1 : 3-diol) buffer, *p*H 7·4, containing 0·02 *M* sodium ethylenediamine tetraacetate. For the estimation of total hæmatin the weighed nodules were ground in this medium with the addition of sufficient sodium dithionite to exclude dissolved oxygen. The ground material was transferred to a Thunberg tube, pyridine was added to 30 per cent (v/v) and the tube evacuated. The contents of the tubes showed the spectrum of pyridine protohæmochromogen when viewed with a Zeiss pupillary spectroscope against a strong light. The concentration of hæmochromogen was estimated by comparing the spectrum of the vacuum tube contents with that of a pyridine hæmochromogen standard derived from bovine hæmin in the spectrocolorimeter described by Hill[9]. These measurements (Table 1) confirm the results of Egle and Munding[7] and extend them to the genus *Casuarina* in which the level of hæmatin was always higher than in the other genera and was, in fact, comparable with that in leguminous root nodules[3].

Spectroscopic examination of preparations of *Casuarina* nodules ground in the *tris* medium with dithionite showed a diffuse absorption band with a maximum at 562 mμ. This band is similar to that of deoxygenated hæmoglobin and is unlike the sharp α-band of a cytochrome or hæmochromogen. An attempt was made to observe the oxygenated compound by omitting dithionite from the grinding

Table 1. TOTAL HÆMATIN CONTENT OF NODULE AND ROOT TISSUES

	μmoles hæmatin/gm. fresh weight (× 10^3)	
	Nodules	Root cortex
Alnus glutinosa	4·85	0·6
Myrica gale	5·5	0·5
Hippophaë rhamnoides	4·2	0·5
Casuarina cunninghamiana	12·0	0·7
Pisum sativum	10·8	—

medium. Rapid spectroscopic observation immediately after grinding then showed two absorption bands, with maxima at 580 mμ and 544 mμ, resembling those of oxyhæmoglobin. This spectrum was ephemeral and the bands rapidly faded as the tissue debris became discoloured by the phenol oxidase activity; the change might have been due to oxidation of hæmoglobin iron by quinones produced by the phenol oxidase[2]. An indication that oxidation to a compound similar to methæmoglobin had occurred was obtained by adding fluoride to the preparation, when an absorption band, resembling that of fluoride methæmoglobin, appeared at 610 mμ.

Although these observations suggested that *Casuarina* nodules contain a pigment with the spectroscopic properties of a hæmoglobin, the rapid disappearance of the oxyhæmoglobin type of spectrum in the macerated preparations made it difficult to establish that the pigment can undergo alternate deoxygenation and oxygenation without change in valency of the hæm iron. This capacity for reversible combination with molecular oxygen is the essential property of hæmoglobin and is the basis of its function as a respiratory pigment. Unequivocal evidence on this point was, however, obtained by spectroscopic examination of the intact nodules. For this purpose a small cluster of nodules was mounted in a drop of the *tris* medium in a cell on a microscope slide. When the cluster was illuminated, on the microscope stage, by the condensed light of a 500-watt projection lamp, sufficient light was transmitted by the less-opaque portions of the nodule cluster for spectroscopic examination to be made, using a 16-mm. objective with the Zeiss pupillary spectroscope as ocular.

With the untreated nodules a spectrum with two absorption bands, at 580 mμ and 542 mμ, could easily be observed. When a small amount of sodium dithionite was added to the fluid surrounding the nodules the two bands were slowly replaced by a single diffuse band at 562 mμ. What is more significant, however, is that when the dithionite solution was then replaced by fresh *tris* medium the two-banded spectrum reappeared. This sequence of events also occurred in the absence of a reducing agent if the nodules were allowed to respire the dissolved oxygen in the fluid surrounding them and air was then readmitted. Confirmation that the hæm iron of the pigment is in the ferrous state *in vivo* was obtained by treating the nodules with carbon monoxide, when two diffuse absorption bands at 572 mμ and 542 mμ replaced the characteristic spectra of either the oxygenated or deoxygenated derivative. The hæm pigment of *Casuarina* root nodules appears, therefore, to possess the essential properties of hæmoglobin.

An estimate of the proportion of the total hæmatin occurring in the form of hæmoglobin was obtained by grinding nodules in the *tris* medium with added dithionite, treating the preparation with carbon monoxide in a Thunberg tube, and comparing the spectrum of the tube contents with that of a standard solution of carboxymyoglobin prepared from sperm whale muscle. In nodules containing 0·11 μmole total hæmatin/gm. fresh weight, carboxyhæmoglobin accounted for 0·083 μmole.

The hæmoglobin of leguminous root nodules is readily extracted by aqueous solvents[3]. That of *Casuarina*, on the other hand, remains firmly bound to the cell debris under all the extraction conditions so far examined. Spectroscopic evidence was obtained that the nodules of *Alnus* and *Myrica* also contain a bound form of hæmoglobin similar to that in *Casuarina*. It is hoped to confirm this when material becomes available in the next vegetative season.

The above observations represent the second finding of hæmoglobin in higher plants; they emphasize the connexion that appears to exist between symbiotic nitrogen fixation and the presence of the respiratory pigment, but go no further towards an explanation of the nature of this connexion.

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Occurrence of a Non-Fibrillar Elastin in the Earthworm

The cuticle of the earthworm's gizzard is generally thought to be chitinous; but there was no experimental evidence for this view, until the observation by Rudall[1], who obtained an X-ray diffraction diagram similar to that found in *Aphrodite* bristles previously described by Lotmar and Picken[2] as a modified chitin (β-chitin). Although after purification he obtained a different diagram, he nevertheless concluded that the gizzard membrane was probably chitinous in nature. This identification is much less convincing in view of the fact that the structural proteins are always found together with a certain amount of polysaccharides[3].

As a part of a more comprehensive study of the earthworm gut[4], I have tried to ascertain the chemical nature of the gizzard cuticle by means of histochemical, physical and chemical methods.

(1) *Histochemical results:*

(*a*) *Polysaccharides.* No specific polysaccharide test gave any truly positive results. The periodic acid–Schiff reaction gives the cuticle a rose tinge, and alcian blue stains it only after oxidation by the acid permanganate reagent.

(*b*) *Elastins and collagens.* Whereas the ectodermal cuticle and the epithelial basement membrane show the same affinities as the collagens, the gizzard cuticle responds positively to tests for elastin. No other structure in the earthworm shows the same combination of tinctorial properties (Table 1).

(2) *Physical and chemical results*: The properties of the gizzard cuticle isolated by dissection are the same as those of vertebrate elastin, except for birefringence and autofluorescence (Table 2). These last properties are probably connected with the

Table 1

Test	Elastin (vertebrate)	Collagen (vertebrate)	Cuticle (gizzard)
Tetrazotized benzidin	brown	purple-brown	brown
The same, after moderate benzoylation	yellow	purple	yellow
Gomori (following Gabe)	violet	blue	violet
Van Gieson	yellow or rose	red	rose
Weigert's resorcin	violet	rosish	violet
Orcein	red	brownish	red

Table 2

Test	Vertebrate elastin	Vertebrate collagen	Arthropod chitin	Earthworm skin cuticle	Gizzard cuticle
Birefringence	weak	positive		positive	negative
Autofluorescence	positive	negative		negative	negative
'Solubility' in 5 per cent pot. hydrox. at 100° C. in 24 hr.	insoluble	soluble	insoluble	soluble	insoluble
'Solubility' in 6 *N* hydrochloric acid at 20° C.	insoluble	soluble	soluble	soluble	insoluble
'Solubility' in 2 per cent acetic acid	insoluble	soluble	insoluble	soluble	insoluble
Pepsin	very resistant	soon attacked	fully resistant	soon attacked	not attacked after 6 hr.
Trypsin	very resistant	attacked after mechanical mincing	fully resistant	soon attacked	not attacked after 6 hr.

particular physical structure of these cuticular membranes. In fact, they do not show any fibrillar structure, whether examined by ordinary or phase-contrast microscopy.

(3) *Chromatographic results:* 12 gizzard cuticles from the earthworm *Lumbricus rubellus* were purified and hydrolysed following a modification of the technique described by Neumann and Logan[5]. The hydrolysate was run on a circular chromatogram with the mixture butanol/acetic acid/water (4 : 1 : 1), and visualized with ninhydrin. Although no quantitative analysis was made, proline, valine and glycine seem to be particularly abundant. Hydroxyproline, typical of collagens and elastin, was detected on a separate chromatogram by the 'dipping' method of Jepson and Smith[6].

I conclude, therefore, that histochemical, physical and chemical evidence agrees with the view that the cuticle of the earthworm gizzard is an elastin in nature. This particular one is a 'non-fibrillar' elastin, analogous to the secreted collagens previously described in some invertebrates, notably in the ectodermal cuticle of *Lumbricus*[7]. I suggest calling it a 'secreted elastin'.

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RADIOBIOLOGY

Fall-out Radioactivity in Southern Sweden

A high enrichment of radioactive fall-out products was recently reported in plant ash from southern Sweden[1]. The highest values were recorded in plants growing near the coast or upon pronounced hills, while plants growing in lowland regions at greater distances from the sea gave the lowest values. In all the samples examined the natural radioactivity was quite subordinate to the radioactivity caused by fall-out.

With the view of a more detailed investigation of the distribution of fall-out radioactivity in the soil and in the vegetation, the ash of different parts of a spruce taken from an area of comparatively high fall-out radioactivity was examined by means of a Geiger counter (Table 1).

Table 1. Relative Radioactivity Values (Background, 1·0) of Ash of Different Parts of 6 m. High Spruce from Romeleasen (120 m. above Sea-level), Southern Sweden, collected and analysed in October 1959

	Age	Ash (per cent)	Relative radioactivity
Needles	1 year	3·6	1·2
Needles	2 years	3·6	1·8
Needles	3 years	4·7	1·8
Live twigs	1 year	3·2	1·6
Live twigs	2 years	2·0	3·6
Live twigs	3 years	2·3	3·8
Dead twigs		1·8	3·3
Trunk, bark		2·8	1·8
Trunk, wood	1 year	0·7	1·0
Trunk, wood, central		0·3	1·0
Root, bark		3·1	1·0
Root, central		0·3	1·0
F-layer soil profile		12·8	1·3
Mineral soil		—	1·0

It appears from these figures that there is a marked enrichment of radioactive substances in both the twigs and the needles. On the other hand, no increase of radioactivity was found in the woody parts of the trunk or of the root or in the bark of the root.

Some γ-spectrometric analyses of parts of the spruce (ashed samples) have been carried out through the courtesy of Dr. K. Edvarson at the Swedish Research Institute for National Defence. These analyses revealed that the percentage of cæsium-144 and niobium–zirconium-95 was more than ten times higher in 1·5-year-old twigs and needles than in those of age 0·5 year. The radioactivity of the central woody part of the trunk was far below that of the exposed parts of the tree and was dominated by potassium-40. The γ-spectrometric analyses demonstrate the decrease in fall-out radioactivity during the last season and also the almost complete absence of fall-out products in the woody parts of the tree.

Additional Geiger-counter measurements have shown that dead parts of trees and plants (dry twigs, etc.) often have as high a radioactivity as live parts, even if they have been dead for several years. The decrease in radioactivity with time is the same for these dead parts as for the live parts of the plants, and it is evident that this radioactivity is due to the presence of relatively short-lived radioactive isotopes. This indicates, when considered together with the observations reported above, that the fall-out radioactivity, or at least the dominating part of it, has been mainly taken up by exposed parts of the plants directly from the air and only to a very small extent from the soil through the root-system of the plant. This observation is in line with what is mentioned by Gorham[2], namely, that certain small plants which have a low ash content and a corresponding large surface show a considerable enrichment in fall-out products.

It is thus evident that the main part of the fall-out radioactivity is now concentrated in the vegetation and in the uppermost layer of the soil where decaying plant parts dominate. This is especially the case with the more short-lived fission products, whereas the

long-lived ones will possibly reach a higher enrichment through a more complete soil–plant–soil cycle.

Autoradiographic exposures of plants, plant parts, and of ashed-plant samples demonstrate the same distribution of radioactivity as mentioned above. There is a marked blackening of the photographic film by needles, leaves, twigs, and bark, contrary to the wood which does not affect the photographic film. The autoradiographs show, furthermore, that there are two kinds of radioactive influence. The first and general type causes a slight blackening of the photographic film. The second type is found when examining more recent samples, and it causes the development of small, intensely black dots on the film. These autoradiographic analyses signify that there are at present two sizes of fall-out particles, one very fine-grained and the other more coarse-grained, the latter representing a highly concentrated radioactivity.

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Calcium Binding in Homogenates of Ehrlich Ascites Tumour Cells

We have recently been attempting to determine the amount of bound (non-diffusible) calcium in the cells of the mouse Ehrlich ascites tumour. Results not yet published indicate that more than 50 per cent of calcium-45 incorporated *in vivo* by the cells is removed by briefly washing them three times in calcium-free balanced salt solution.

In order to investigate further the bound calcium, we disrupted the cells and examined the homogenate. This was done by suspending the cells, which had been labelled *in vivo* with calcium-45, in ice-cooled buffered isotonic salt solution, and then disrupting them by exposure to ultrasonic vibrations of about 20 kc./s. for 2 min. with the *M.S.E.*–Mullard apparatus. The resulting homogenate was subjected to a conventional dialysis procedure at 4–6° C. against a calcium-free solution. Initially calcium-45 was lost from the homogenate very slowly, as indicated by the slight increase in the radioactivity of the solution against which it was dialysed (Fig. 1). This phase lasted about 90 min., after which calcium was lost rapidly, as shown by the steep portion of the curve of radioactivity of the dialysing solution. A similar curve is obtained even if the isotope is added to homogenized cells *in vitro*. A totally different curve is obtained on dialysing ascitic fluid, in which there is a bound, but exchangeable, calcium fraction. In this case, the increase in radioactivity of the solution against which the labelled fluid is dialysed shows a steep rise from zero time, and flattens only when equilibrium is nearly attained (Fig. 1).

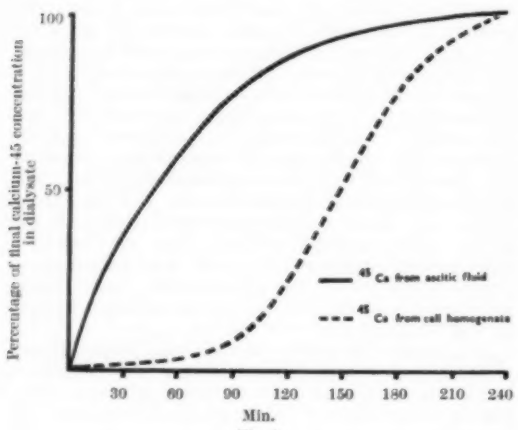

Fig. 1

Preliminary experiments also indicate that the total amount of calcium-45 removed from the labelled homogenate by dialysis, even after 4 hr., is considerably less than that extracted by quickly washing the cells in calcium-free solution, and probably amounts to less than 20 per cent of that initially present.

This increase of binding of calcium-45, and hence of total calcium, is corroborated by the very slow migration of the tag towards the cathode from the point of application of the labelled homogenate, when this is subjected to paper electrophoresis.

It appears that, as a result of the disintegration, a number of new calcium-binding sites have been made available. The increase in base-binding capacity may be accounted for, *inter alia*, by (*a*) molecular damage produced by subjection to the ultrasonic vibrations, or (*b*) by existing groups, previously inaccessible to the base, being made available by disruption of the cells.

Clearly, a study of the normal distribution of calcium in different cell fractions would be falsified by the increase in the proportion of bound calcium produced by ultrasonic disruption. We are therefore investigating further the nature of the binding in whole cells and in homogenates.

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VIROLOGY

Purification and Properties of Cauliflower Mosaic Virus

Strains of cauliflower mosaic virus occur very commonly throughout North America and Europe. Previous attempts to determine the morphology of the virus[1], and to obtain an antiserum to it[2], were unsuccessful. Following the recent purification of cucumber mosaic virus[3], an attempt was made to purify cauliflower mosaic virus using similar procedures.

The cabbage virus *B* strain of the virus, described by Walker *et al.*[4], was mechanically inoculated to leaves of young tendergreen mustard plants (*Brassica perviridis* Bailey). Two to three weeks after inoculation, systemically infected leaves were harvested and homogenized in a Waring blendor in 0·5 *M* potassium phosphate buffer (*p*H 7·5) containing 0·1 per cent thioglycollic acid, at the rate of 12 ml. of buffer for each 10 gm. of leaf tissue. The homogenate was strained through cheese-cloth and *n*-butanol added dropwise with constant stirring to give a final butanol concentration of 8 per cent. The mixture then was stirred for 1 hr., after which it was

centrifuged for 15 min. at 5,000 r.p.m. in a model *SP* Servall centrifuge. The clear supernatant was filtered through glass-wool and centrifuged for 2 hr. at 30,000 r.p.m. in a No. 30 rotor of a Spinco model *L* ultracentrifuge. Following ultracentrifugation, the supernatant was discarded and the pellets resuspended in 2–3 ml. of distilled water, and placed on a mechanical shaker for 8–10 hr. The pellet suspension was then centrifuged for 1 min. at 25,000 r.p.m., and the pellet discarded. All operations were carried out at 2–4° C.

Electron microscopic examination of grids sprayed with the final supernatant revealed particles of two sizes, 18 mμ and 50 mμ, while healthy leaf extracts processed in the same manner contained only the smaller particles.

Further purification was achieved by density gradient centrifugation. 1-ml. aliquots of the partially purified virus were layered on to tubes containing 30 ml. of a 5–40 per cent sucrose gradient and centrifuged in a Spinco *SW*-25 rotor for 2 hr. at 25,000 r.p.m. Examination of the gradient tubes under a beam of light revealed an opalescent band midway down the tubes. No such band was present in healthy preparations treated in a similar manner. The material within the bands was carefully withdrawn with a hypodermic needle through the side of the tubes, and dialysed for 12 hr. against distilled water. These virus preparations were assayed for infectivity on tendergreen mustard and typical symptoms of the disease appeared 10–20 days following inoculation, the time varying with the dilution of the virus preparation. These preparations were infectious up to dilutions of 10^{-5}. Aliquots of these preparations were sprayed on collodion-coated electron microscope grids, freeze-dried, and shadowed with uranium. When examined with the electron microscope, the grids sprayed with the virus showed numerous uniform spheres with an average diameter of 50 mμ. None of the smaller particles observed in partially purified preparations was present (Fig. 1).

The purified virus, suspended in 0·02 *M* sodium phosphate buffer (*p*H 6·0), was found to have a sedimentation coefficient of approximately 222 *S* at 20° C. when centrifuged in a Spinco model *E* ultracentrifuge at 17,980 r.p.m.

Purified preparations of the virus were injected into rabbits intramuscularly, using Freund's adjuvant, and intravenously, at 7–10 day intervals for a total of 6 injections. The rabbits were bled 10 days after the last injection. Serum used in ring tests with the virus gave positive reactions at serum dilutions up to 1/512. The virus did not react with normal serum, or with antisera of turnip yellow mosaic or turnip mosaic viruses. Purified preparations of turnip yellow mosaic and turnip mosaic viruses gave no reaction when tested against cauliflower mosaic virus antiserum.

We wish to express our thanks to Dr. P. J. Kaesberg, Dr. J. J. Kelley and Mrs. Selma Sachs of the Department of Biochemistry, University of Wisconsin, for their assistance with the electron microscope and sedimentation coefficient studies.

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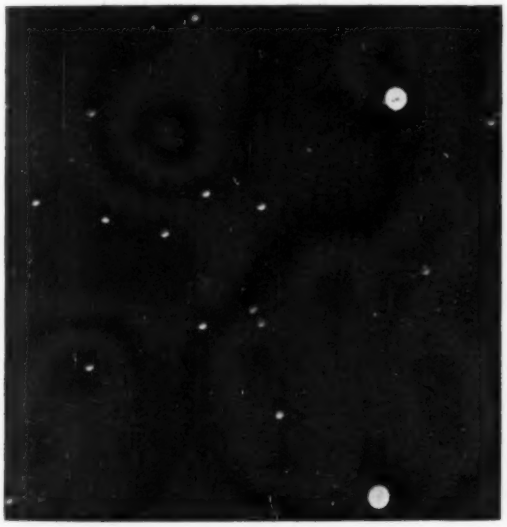

Fig. 1. Electron micrograph of purified cauliflower mosaic virus (× 24,490). The large white spheres are polystyrene latex particles, 122·5 mμ in diameter

Decarboxylation of Glutamic Acid in Tobacco Leaves inoculated with Tobacco Mosaic Virus

THE process of decarboxylation of glutamic acid has been a subject of interest since the discovery in many plants of γ-amino-butyric acid in large quantities[1–3].

Since proteins do not contain these acids, the role of the process of decarboxylation is not quite clear. But the appearance of the process at all the stages of development suggests that its role in plant metabolism may be more general[4,5].

I have examined the intensity of decarboxylation in *Nicotiana tabacum* var. White Burley, inoculated with tobacco mosaic virus. Typical results are given in Table 1. The results show that at certain stages of the mosaic disease the activity of the process increases.

Table 1. ACTIVITY OF GLUTAMIC ACID DECARBOXYLASE IN TOBACCO LEAVES HOMOGENATES

Days since inoculation	Carbon dioxide (μl.) in 30 min. at 30° C.		Activation (per cent)	Atmosphere
	Sound	Infected with tobacco mosaic virus		
6–8	51·8	57·1	110	Air
	56·4	89·3	158	
6–8	47·8	67·0	141	Nitrogen
	51·9	73·0	140	
11–14	47·8	100·6	210	Air
	51·9	116·0	220	
11–14	46·8	67·7	144	Nitrogen
	35·5	76·1	214	

5 gm. of the tissue with 15 ml. 1/15 *M* phosphate buffer *p*H 5·6 was ground until a homogeneous suspension was obtained. 0·2 ml. homogenate and 1 ml. glutamic acid in concentration 0·02 *M* were poured into a Warburg apparatus.

The greatest intensity of decarboxylation in leaf homogenates was found in young leaves when the mosaic began to appear (11–14 days after infection)—the activation reaching 200 per cent. The second maximum of the decarboxylation of glutamic acid was observed several days after inoculation (140 per cent).

To explain the increase in decarboxylation of glutamic acid found in tobacco leaves inoculated with tobacco mosaic virus, I suggest the phenomenon is connected with destructive metabolism because maximum intensity of the process occurs when the disorder symptoms begin to appear, or it may be involved in the synthesis of virus proteins.

The second view is backed by indirect results of other workers. Analysing free amino-acids in the coconut endosperm, Baptist found that the γ-amino-butyric acid appears in the period of intensive protein synthesis[6]. Pekka and Virtanen have shown that metabolism of γ-amino-butyric acid is strictly connected with glutamine, which is assumed to play an important part in protein synthesis[7]. The examination of the process and its role in virus synthesis is being continued.

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BACTERIOLOGY

Streptomycin-induced Lysis of Penicillin-treated *Staphylococci*

When growing cultures of *Escherichia coli* are exposed to bactericidal concentrations of penicillin, lysis of the cells occurs after 20–30 min.[1]. This lysis appears to be caused by the inhibition by penicillin of synthesis of cell wall mucopeptide with continuing synthesis of other cell constituents, resulting in 'bursting' of the cells[2]. Other cases of lysis of bacteria due to such a reduced differential rate of synthesis of cell wall mucopeptide are known, and have recently been reviewed[3,4].

When penicillin, at a minimally bactericidal concentration (0·06 μgm./ml.), is added to growing cultures of *Staphylococcus aureus* (strain Duncan), rapid lysis of the cells does not occur although the synthesis of cell wall mucopeptide ceases after about 15 min.[5]. Only a very slow fall, continuing for more than 24 hr., is observed in the optical density of such cultures, and it is not clear why the rate of lysis in these *Staphylococci* is so low compared, for example, with penicillin-treated *E. coli*[1,3] or lysine-deficient *Streptococcus faecalis*[6]. One possibility which suggests itself is that, due to the reduced activity of amino-acid-accumulating systems in *Staphylococci* which follows contact with penicillin[5,7], the rates at which cell constituents other than the cell wall can be synthesized are reduced, so that 'bursting' occurs more slowly.

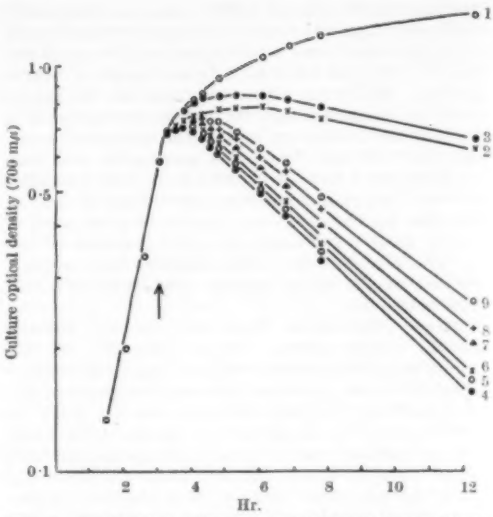

Fig. 1. To identical cultures of *Staphylococcus aureus* (strain Duncan) growing in *PG* medium (ref. 9) at 37° in shake flasks, additions were made (at the time indicated by the arrow) of streptomycin (10 μgm./ml.) (*S*) and/or penicillin (0·06 μgm./ml.) (*P*) as follows. *S* (curve 1); *P* (curve 2); *S* followed after 30 min. by *P* (curve 3); *P* and *S* together (curve 4); *P* followed by *S* either after 10 min. (curve 5), after 20 min. (curve 6), after 30 min. (curve 7), after 40 min. (curve 8), or after 50 min. (curve 9)

During investigations of the effects of streptomycin on *S. aureus*, I have recently observed, however, that addition of streptomycin together with penicillin (each at minimally bactericidal concentrations) to exponentially growing cultures brings about rapid lysis (Fig. 1). This lysis begins at *c.* 30 min. after addition of streptomycin, even when this is delayed up to 50 min. after addition of penicillin. Although the rate of lysis is independent of the concentration of streptomycin when this is greater than 10 μgm./ml., lysis commences earlier at higher streptomycin concentrations. Lysis is induced only by those derivatives of streptomycin which possess anti-bacterial activity (dihydrostreptomycin, mannosido-

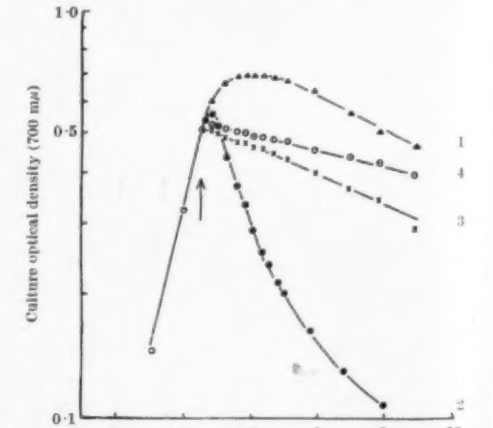

Fig. 2. To cultures growing as in Fig. 1 were added (at the time indicated by the arrow): penicillin (0·06 μgm./ml.) (curve 1); penicillin (0·06 μgm./ml.) + streptomycin (10 μgm./ml.) alone (curve 2), or together with chloramphenicol (50 μgm./ml.) (curve 3), or together with 8-azaguanine (500 μgm./ml.) (curve 4)

streptomycin) and not by streptidine or streptomycinic acid; it does not occur under anaerobic conditions, when the bactericidal effect of streptomycin on this organism is also much reduced. Essentially similar results have also been obtained using strain *H* of *S. aureus*.

When the growth-rate of a culture, previous to addition of penicillin and streptomycin, is reduced by decreasing the concentration of peptone in the growth medium, the rate of subsequent lysis is reduced proportionally. Lysis can be almost completely prevented by addition, simultaneously with penicillin and streptomycin, of chloramphenicol (50 μgm./ml.) or 8-azaguanine (500 μgm./ml.) (Fig. 2). However, chloramphenicol can prevent the bactericidal effect of streptomycin on *S. aureus* (Hancock, R., unpublished results), so that this finding does not necessarily indicate that lysis under these conditions is a result of 'unbalanced synthesis' of other cell constituents relative to cell wall. The possibility that lysis may be caused by cell wall-degrading enzymes of the type found in *Staphylococci* by Mitchell and Moyle[8] seems unlikely since we have not been able to detect any activity of these enzymes in cells after growth for 30 min. in the presence of streptomycin.

I am grateful to Mr. F. McManus for valuable technical assistance, and to the Distillers Co. and to Merck and Co., Inc., for gifts of streptomycinic acid and streptidine, respectively.

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Influence of Light on Bacterial Flora of Roots

Although considerable work has been done on the influence of various factors such as type, moisture content, reaction and treatment of the soil and kind and age of plant on the microflora of the rhizosphere[1], very little has appeared concerning the response of the normal rhizosphere micropopulation to the changes in plants growing under different light intensities. The studies that have been made deal primarily with specific phenomena such as symbiotic nitrogen fixation[2], mycorrhizal development[3] and susceptibility of roots to infection[4]. However, Rovira[5] has recently reported that "the numbers of bacteria in the rhizosphere of tomato were reduced by 60 per cent when plants were shaded to 40 per cent of full sunlight"; the conditions under which the plants were grown were not given. We have recently completed experiments on the influence of light on the microbial population of wheat roots. These were selected for analysis rather than the soil adhering to them because it was considered that the organisms in intimate contact with the roots would reflect more accurately the changes produced in the plant by differences in illumination than would the organisms in the rhizosphere soil, where a dilution of the effect would probably occur. Certain of our findings relating to the bacterial flora are presented here. Full details of these experiments will be published elsewhere.

Wheat was planted in field soil in large rectangular tanks in the greenhouse. The plants were grown under 'normal light' for two weeks after which a cheesecloth cage was placed over half of them, thus reducing the light from approximately 1,000 to about 300 foot-candles. The temperature at the soil-level showed little significant variation between the illuminated and 'reduced light' sets. Moisture was maintained at about 70 per cent of the soil-moisture holding capacity by regular sprinkling. Composite root-samples were obtained three weeks after shading by removing plants from four locations in each treatment. The roots were thoroughly washed for 5 min. by shaking in sterile water and then washed aseptically in three changes of water prior to homogenization in a sterile Waring blendor. The homogenate was analysed microbiologically using methods described in previous publications from this laboratory[6,7]. The results of a typical experiment are summarized in Table 1.

Table 1. Influence of Illumination on the Bacterial Flora of Wheat Roots*

Bacteria	Illumination (ft.-candles)	
	1,000	300
Plate count	7·9	3·9
Methylene blue reducers	50·0	6·0
Glucose fermenters		
Acid producers	3·0	0·38
Gas producers	0·3	0·06
Ammonifiers†	16·0	0·2
Incidence of amino-acid requiring bacteria (per cent)	65	30

* Numbers in thousand million per gm. oven dry roots; methylene blue reducers, glucose fermenters and ammonifiers were estimated by the ultimate dilution procedure (ref. 7).
† These results were derived from a later experiment.

A distinct reduction in bacterial count and in numbers of methylene blue-reducing organisms (as an index of the overall activity on the root surface) as well as of glucose-fermenting bacteria occurred on the roots of plants grown under low light intensity. Further tests revealed that numbers of ammonifying bacteria were also reduced on these roots. Nutritional studies on isolates from the plates used for counting showed a marked reduction in the percentage incidence of bacteria requiring amino-acids for maximum growth from about 65 per cent to 30 per cent. Taxonomic studies with these isolates are in progress. The results suggest that there is both a quantitative and a qualitative change in the substances excreted by these roots which normally stimulate the microflora at or near the root surface and produce the 'rhizosphere effect'[1]. Of course the reduced amounts of these materials, particularly of amino-acids, at the root surface may be due partly to the decrease in the total bacterial population on the root, resulting in a concomitant reduction in the elaboration of various substances, including amino-acids[8]. Rovira[5] has reported a reduction in excretion of certain amino-acids by the roots of plants grown aseptically under reduced light, but mentioned also that the presence of micro-organisms influenced the concentration of amino-acids in the solution surrounding tomato roots. However, the numbers of bacteria which do not require amino-acids and which may liberate them appear to be very similar on the roots

of both sets of plants used in the present experiments (35 per cent of 7·9 = 2·76 thousand million in the 'high light' series as compared with 70 per cent of 3·9 = 2·76 thousand million in the 'low light' set). The plant, therefore, may be the major source of amino-acids for these organisms requiring them.

The significance of these observations with regard to plant nutrition, growth or susceptibility to disease is difficult to assess, especially since the role of the normal rhizosphere soil and root-surface microflora is still imperfectly understood. Eaton and Rigler[9] have reported decreased susceptibility of cotton plants to *Phymatotrichum omnivorum* as a result of defoliation or mutilation of the plants, which increased the carbohydrate content of the roots. This effect was associated also with a reduction in total bacterial numbers and an increase in numbers of fluorescent bacteria. Harley and Waid[10] observed an increase in the incidence of semi-pathogenic fungi on roots of beech seedlings grown in the shade. Whether these results are due to a concomitant reduction of the bacterial and possibly of the actinomycete population at the root surface, to an alteration of the types of organisms, as suggested above, or to changes in the plant and in the root which render them less able to withstand parasitic attack is not clear at present although the increased susceptibility of plants growing under reduced illumination to diseases produced by viruses, fungi and nematodes has been reasonably well established[11,12].

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Iron Bacteria in Mine-waters

As van Beneden[1] has shown, iron bacteria may be obtained from fresh-water by reducing the iron in this water by percolation through a layer of soil. In the thin layer where the effluent oxidizes (presumably ferrous carbonate or bicarbonate to hydrated ferric oxide) the bacteria develop.

Baas Becking, Wood and Kaplan[2], using this method, obtained iron bacteria from sea-water. With the help of Mr. A. D. Haldane, senior chemist of the Bureau of Mineral Resources, a more efficient apparatus was constructed. Iron bacteria were grown on slides on which a reduced fresh-water effluent was dripping. Tap-water can be made free of oxygen by passing it through a column of steel-wool, previously washed in carbon tetrachloride. The effluent contains a slate-blue compound, possibly ferrous hydroxide, which oxidizes slowly to hydrated ferric oxide. Ferrous carbonate (and possibly the soluble bicarbonate) are formed and oxidized in culture flasks containing the infection material and a small amount of magnesium-ammonium phosphate.

As infection material, chalybeate waters from various localities in New South Wales were used (Matraville, Mittagong, Warrah, Palm Cave, Bungendore). Both a sheathed rod and a species of *Sphaerotilus* made their appearance. The method, however, is cumbersome and unsuitable for pure culture work.

The oxidation of pyrite proceeds in sterile suspensions, yielding ferrous sulphate and acid. In sterile suspensions, the oxidation of ferrous to ferric sulphate is very slow, only a few per cent being converted in four months at room temperature.

Iron bacteria isolated from chalybeate waters are capable of catalysing the oxidation of ferrous to ferric sulphate, the reaction running to completion in a few weeks at room temperature. It is possible to obtain pure cultures of these forms on 1 per cent ferrous sulphate agar containing 200 mgm./l. magnesium-ammonium phosphate. Pure cultures could also be obtained on powdered pyrite agar.

One of the final oxidation productions of pyrite is a mixture of ferric sulphates and oxysulphates, called 'yellowboy' by the miners. This ore, collected from various levels, Lake George Mine, Captains Flat, New South Wales, proved to contain *Sphaerotilus* and also *Gallionella*. The former could be isolated on 1 per cent ferrous-sulphate agar and on pyrite agar. Mine-water from the same mine contained *Sphaerotilus*.

A constant companion of both *Sphaerotilus* and the bacillary form is a small *Torulopsis*-like yeast, present in both mine-water and fresh-water, which also appeared from hydrated iron oxide collected near a hot spring at Talasea, New Britain.

Gallionella could not be isolated on sulphate media, but there are, apparently, iron organisms capable of developing on the ferrous (bi)carbonate as well as on the ferrous sulphate system.

In the latter system they give rise to electrode potentials of +860 mV.

The first stage in the oxidation of pyrite, where ferrous sulphate and acid are formed (*p*H 1·5–3·0), is a purely chemical phase, as the oxidation proceeds with equal intensity in sterile and in infected materials. In the second phase the biological catalyst will create an environment with very high electrode potentials, the *p*H remaining almost the same.

In old plate cultures of *Sphaerotilus* sp. a crust was formed around the bacterial colonies. In certain instances material from these crusts showed, in concentrated solution, a negative *p*H and potentials of more than +900 mV. There are more than 40 ferrous and ferric sulphate minerals described in the literature, and almost invariably they seem to be formed by the oxidation of pyrite in a dry atmosphere.

We can say, therefore, that the desiccation of the bacterial end-products adds a third, final stage to the oxidation of pyrite—a physical phase.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 23

LABORATORY ANIMALS CENTRE (at the Royal Society of Medicine Wimpole Street, London, W.1), at 9.30 a.m.—Symposium on "The Provision of Animals for Cancer Research".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. J. H. G. Lebon and Mr. V. C. Robertson: "Jebel Marra, Darfur, and Its Region".

UNIVERSITY OF LONDON (at the Wright-Fleming Institute of Microbiology, St. Mary's Hospital Medical School, Norfolk Place, London, W.2), at 5 p.m.—Dr. P. L. Mollison: "The Role of Complement in Blood Group Reactions".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. C. Robertson King: "The Retail Distribution of Electricity". (Last of three Cantor Lectures on "Energy".)

Monday, May 23—Saturday, May 28

INSTRUMENTS, ELECTRONICS AND AUTOMATION EXHIBITION (at Olympia, London).*

Tuesday, May 24

UNIVERSITY OF LONDON (at the Imperial College of Science and Technology, London, S.W.7), at 5.30 p.m.—Prof. M. Blackman: "Some Applications of Electron Diffraction Techniques" (Inaugural Lecture).

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. B. Segre (Rome): "Continuous Variation and Homotopy in Algebraic Geometry".* (Further lectures on May 26 and 30).

UNIVERSITY OF LONDON (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 5.45 p.m.—Mr. J. S. Wacher: "Recent Excavations at Catterick and Brough-on-Humber".* (Sixth of nine lectures on "Recent Archæological Discovery in Britain". Further lectures on May 31, June 7 and 14).

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 6 p.m.—Annual General Meeting. 7 p.m.—Mr. R. S. Medlock: Presidential Address.

Wednesday, May 25

SOCIETY OF CHEMICAL INDUSTRY, NUTRITION PANEL (at 14 Belgrave Square, London, S.W.1), at 4 p.m.—Dr. L. J. Teply: "Foods for the Under-developed Countries".

INSTITUTION OF ELECTRICAL ENGINEERS, ELECTRONICS AND COMMUNICATIONS SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "New Semiconductor Devices and their Possible Applications" opened by Dr. A. F. Gibson and Mr. G. King.

POLAROGRAPHIC SOCIETY (at the Royal College of Science, Imperial Institute Road, London, S.W.7), at 7 p.m.—Meeting on "Automatic Analysis by Electrochemical Methods".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. G. F. J. Garlick: "Luminescence—The Cold Light of Physics".

Wednesday, May 25—Friday, May 27

SOCIETY FOR THE STUDY OF FERTILITY (at the Royal Veterinary College; Guy's Hospital Medical School; and the Institute of Obstetrics and Gynæcology, Chelsea Hospital for Women)—Annual Conference.

Thursday, May 26

(In the Physiology Lecture Theatre, Guy's Hospital Medical School, London Bridge, S.E.1), at 5 p.m.—Dr. J. Parizek (Prague): "Sterilization of the Male by Cadmium Salts" (Third Oliver Bird Lecture).

Thursday, May 26

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Dr. A. G. Gaydon, F.R.S., Mr. G. N. Spokes and Mr. J. van Suchtelen: "Absorption Spectra of Low-Pressure Flames": Mr. R. Brailsford, Mr. P. V. Harris and Prof. W. C. Price, F.R.S.: "The Effect of Fluorine on the Spectra and Ionization Potentials of Molecules".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. S. J. Bach: "The Metabolic Fate of Protein-Nitrogen in the Mammal".* (Further lecture on June 2.)

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. P. Waser (Zürich): "The Cholinergic Receptor".*

Friday, May 27

INSTITUTION OF CHEMICAL ENGINEERS (at the Imperial College of Science and Technology, Department of Chemical Engineering, Prince Consort Road, London, S.W.7), at 3.30 p.m.—Mr. J. W. Smith: "Heat Transfer to Liquid Fluidized Beds and to Coarse Suspensions Flowing in a Vertical Pipe".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER (with interests in physical chemistry, preferably in the field of theoretical chemistry) IN THE DEPARTMENT OF CHEMISTRY—The Secretary, The University, Edinburgh (May 28).

PRINCIPAL LECTURER (with high academic qualifications, some industrial and research experience, and preferably teaching experience) IN INDUSTRIAL STATISTICS—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4, quoting "D" (May 28).

ASSISTANT LECTURER or LECTURER (with an honours degree in zoology or a veterinary or medical qualification, and a special interest in experimental helminthology) IN THE DEPARTMENT OF AGRICULTURAL AND FOREST ZOOLOGY—The Registrar, University of North Wales, Bangor, North Wales (May 30).

SCIENTIFIC OFFICER (with a good class honours degree in zoology and some research experience, preferably in soil fauna) at Merlewood Research Station, Grange-over-Sands, Lancs, or Moor House Field Station, Alston, Cumberland, for work on the ecology of moorland invertebrates—The Nature Conservancy (E), 19 Belgrave Square, London, S.W.1 (May 30).

LECTURER IN THE DEPARTMENT OF MATHEMATICAL PHYSICS—The Secretary, The University, Edinburgh (May 31).

LECTURERS IN EXPERIMENTAL AND THEORETICAL PHYSICS—The Secretary of University Court, The University, Glasgow (May 31).

MULLARD RESEARCH FELLOW (preferably with a Ph.D. degree, or with equivalent research experience) IN PHYSICS, for research in various branches of solid-state physics with particular reference to defects, semiconductor or surface properties—The Registrar, University College of North Staffordshire, Keele, Staffs (May 31).

LECTURER, Grade II (with special interests in newer palæozoic stratigraphy and palæontology) IN GEOLOGY—The Registrar, The University, Bristol 8 (June 1).

ASSISTANT LECTURER IN GENETICS IN THE DEPARTMENT OF BOTANY—The Registrar, The University, Leicester (June 4).

DEMONSTRATOR IN ZOOLOGY—The Registrar, King's College (University of Durham), Newcastle upon Tyne 1 (June 4).

FELLOW AND LECTURER IN PHILOSOPHY—The Rector, Exeter College, Oxford (June 4).

LECTURER or ASSISTANT LECTURER IN PURE MATHEMATICS—The Registrar, The University, Leicester (June 4).

ASSISTANT LECTURER (prepared to teach general invertebrate zoology, other than entomology) IN ZOOLOGY—The Registrar, University College of North Wales, Bangor, North Wales (June 6).

LECTURER (with special qualifications in educational psychology) IN EDUCATION—The Registrar, The University Sheffield (June 6).

CHEMIST, Assistant Experimental Officer or Experimental Officer grade (with a degree in chemistry or equivalent qualification and preferably experience in pesticide analysis) IN THE PLANT PROTECTIVE CHEMISTRY SECTION, to assist in studies of pesticides in fruit culture—The Secretary, East Malling Research Station, near Maidstone, Kent (June 10).

ORGANIC CHEMIST (Ph.D. standard) at the Medical Research Council's Carcinogenic Substances Research Unit, University of Exeter, to work with a team investigating the chemistry of tobacco and tobacco smoke—The Vice-Chancellor, The University, Exeter (June 10).

RESEARCH ASSISTANT (with the degree of Ph.D. or about to submit a Ph.D. thesis) IN THE DEPARTMENT OF CHEMISTRY, for work, in collaboration with Dr. J. J. Kipling, involving carbonization of high-molecular weight compounds, graphitization of the resulting carbons, and examination of the physical properties of the product with particular emphasis on adsorption studies—The Professor of Chemistry, The University, Hull (June 11).

SENIOR LECTURER IN THERMODYNAMICS; a SENIOR LECTURER IN ELECTRICITY (heavy and light current); and a SENIOR LECTURER or LECTURER IN FLUID DYNAMICS (hydraulics or aerodynamics)—The Registrar, The University, Leicester (June 11).

SCIENTIFIC OR TECHNICAL ASSISTANT (male, preferably with seagoing or diving experience), to assist in a research programme on the biology of the Western Australian commercial crayfish—The Director, Western Australian Museum, Beaufort Street, Perth, Western Australia (June 14).

LECTURER or ASSISTANT LECTURER IN CHEMISTRY at the University of Malaya (Singapore Division)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 15).

LECTURER/SENIOR LECTURER IN PURE MATHEMATICS at the University of New England, Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 17).

READER IN PHYSIOLOGY at St. Mary's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 21).

CHAIR OF MATHEMATICS in Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 30).

LECTURER (with research experience in the biochemical mechanisms of drug action) IN PHARMACY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 30).

RESEARCH STUDENTS (2) (graduates or students graduating this year in chemistry, biochemistry or physiology) IN THE CANCER RESEARCH DEPARTMENT, for work on biochemical and immunological aspects of carcinogenesis—The Registrar, The University, Nottingham (June 30).

READER IN APPLIED ENTOMOLOGY at Imperial College—The Academic Registrar, University of London, Senate House, London, W.C.1 (July 1).

PROFESSOR (specialist in either applied mathematics or theoretical physics) OF APPLIED MATHEMATICS at Rhodes University, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, July 15).

LECTURER IN PHYSICAL METALLURGY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 16).

LECTURER (with qualifications in either pure or applied mathematics) IN MATHEMATICS at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, August 8).

BOTANIST (PLANT BREEDER) (with a good honours degree in botany and at least two years postgraduate experience, preferably with perennial crops) in Uganda, to breed locally adapted varieties of Arabica coffee resistant to rust; to investigate compatibility systems; and to conduct variety trials on Robusta and Arabica coffee—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/9/034/T.

EXPERIMENTAL STAFF (with a pass degree or H.N.C., and experience in one or more of the following fields: electronics, vacuum techniques, nuclear counting methods, or general experimental physics), to join a team studying experimental nuclear reactors and carrying out general neutron physics research—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 2632/34.

FISHERIES OFFICER (with a good honours degree in natural science (zoology), experience of the inshore fishing industry, and preferably a knowledge of East Africa) in Tanganyika, for the development of marine or inland native fisheries—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/012/T.

LECTURER (with high qualifications in electronics and communications) IN ELECTRICAL ENGINEERING—The Registrar, The University, Bristol.

MASTER (with an honours degree) TO TEACH PHYSICS up to "A" or "S" level—The Headmaster, Westminster School, 17 Dean's Yard, London, S.W.1.

PLANT PHYSIOLOGIST (with a good honours degree in botany or chemistry with specialization in plant physiology and not less than two years suitable postgraduate experience or training) in Tanganyika, for research work on coffee, with particular reference to over-bearing and plant nutrition, and to collaborate with other specialists—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/026/T.

POSTDOCTORAL RESEARCH FELLOWS IN INORGANIC CHEMISTRY, with special reference to transitional metal complexes and organometallic compounds—Prof. G. Wilkinson, Imperial College of Science and Technology, London, S.W.7.

READER (with the qualifications and experience to direct research and postgraduate work, and to take a leading part in advanced training) IN PHARMACOLOGY—The Registrar, Bradford Institute of Technology, Bradford 7.

RESEARCH FELLOW (with a good degree in electrical engineering, physics or chemistry, and some research or industrial experience) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1.

SCIENTIFIC OFFICER, Grade I (honours graduate in zoology, botany or agriculture, a practical knowledge of modern methods of pest and weed control, and preferably administrative ability) IN THE INFESTATION SECTION, British Railways Research Department, Manchester—Director of Research (British Railways), British Transport Commission, 222 Marylebone Road, London, N.W.1.

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